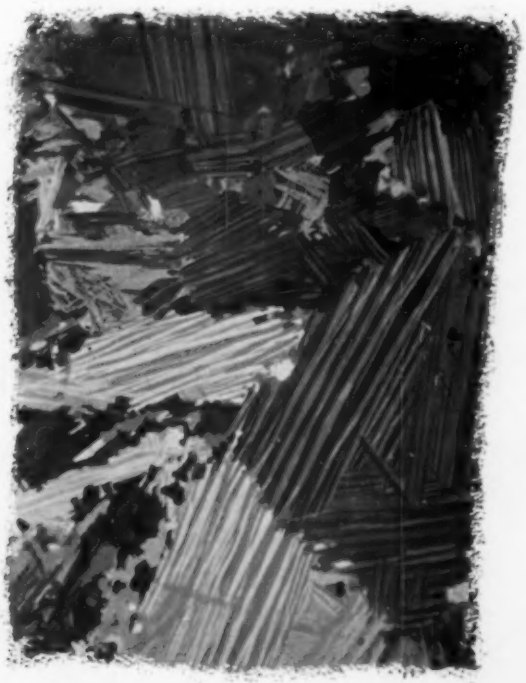
# Metal Progress

JULY 1958



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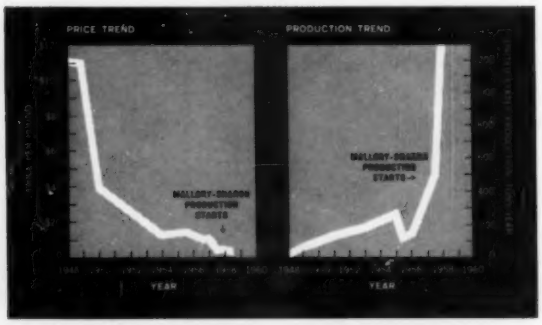
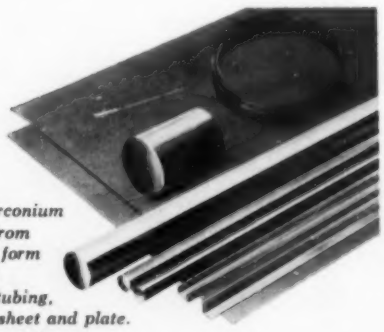



**For lower prices** — *Greater availability will definitely be reflected in lower prices. In many cases, the improved performance of zirconium parts much more than offsets their higher material cost.*



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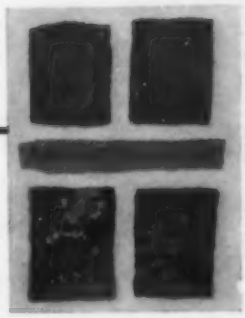
July 1958 . . . Volume 74, No. 1



The color micrographs of uranium carbide were prepared at Oak Ridge National Laboratory to illustrate the lead article by R. J. GRAY, W. C. THURBER and C. K. H. DUBOSE. Cover design by FLOYD E. CRAIG.

**Preparation of Arc-Melted Uranium Carbides, by R. J. Gray, W. C. Thurber and C. K. H. DuBose** ..... 65

Uranium carbides are promising materials for aluminum reactor fuel elements requiring high uranium investments – particularly for the Atoms-for-Peace Program, where the $U^{235}$ enrichment is limited to 20%. Aluminum-uranium carbide fuel plates, fabricated by the picture-frame technique, retain their dimensional tolerance during heat treatment. Microstructures in color (see cover) and in black and white were studied in detail. (M27d, M21, T11g, 17-57; U, 14-68)

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**How to make Hydraulic Tubing Last Longer, by C. S. Yen and J. L. Waisman** ..... 88

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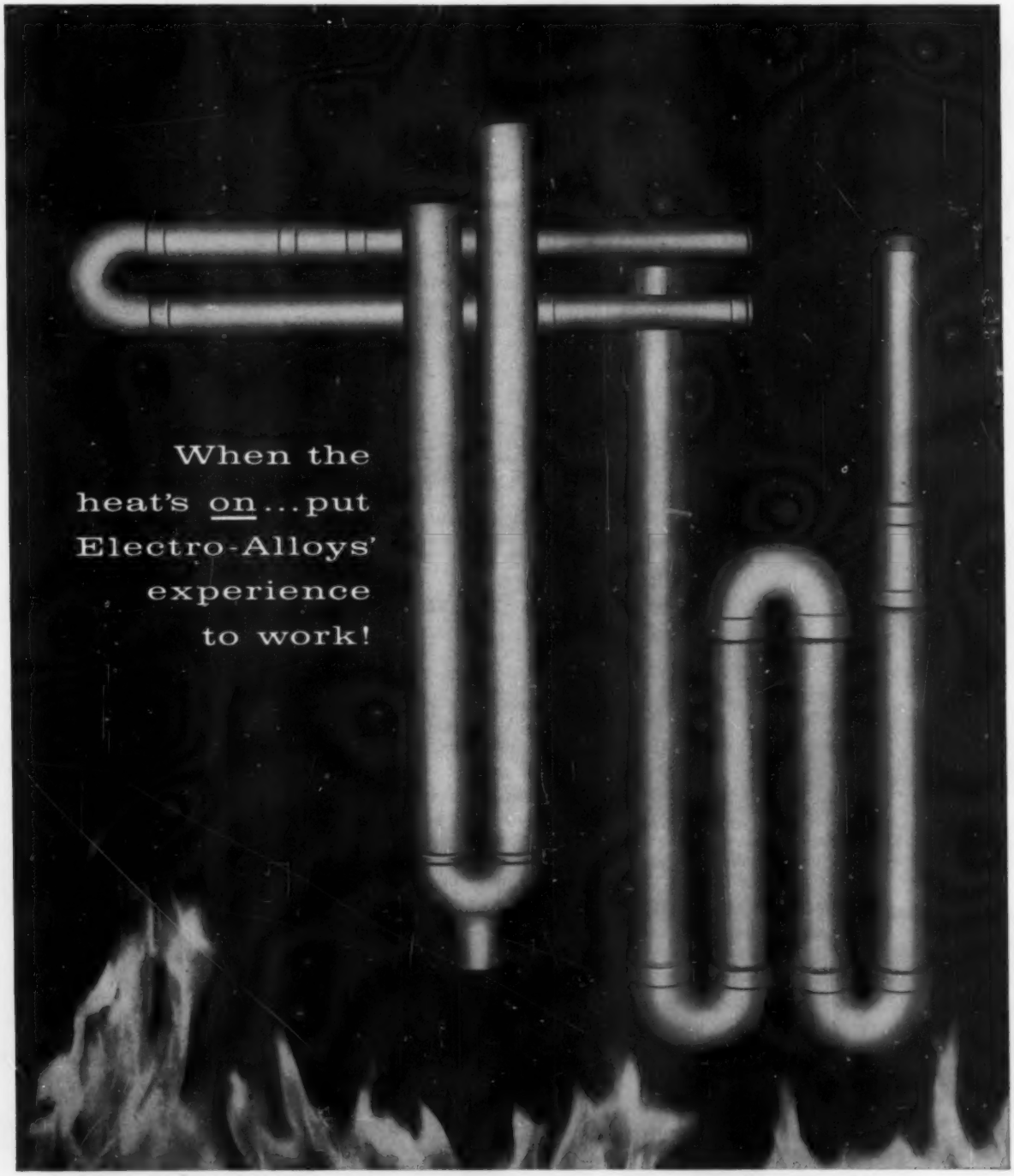


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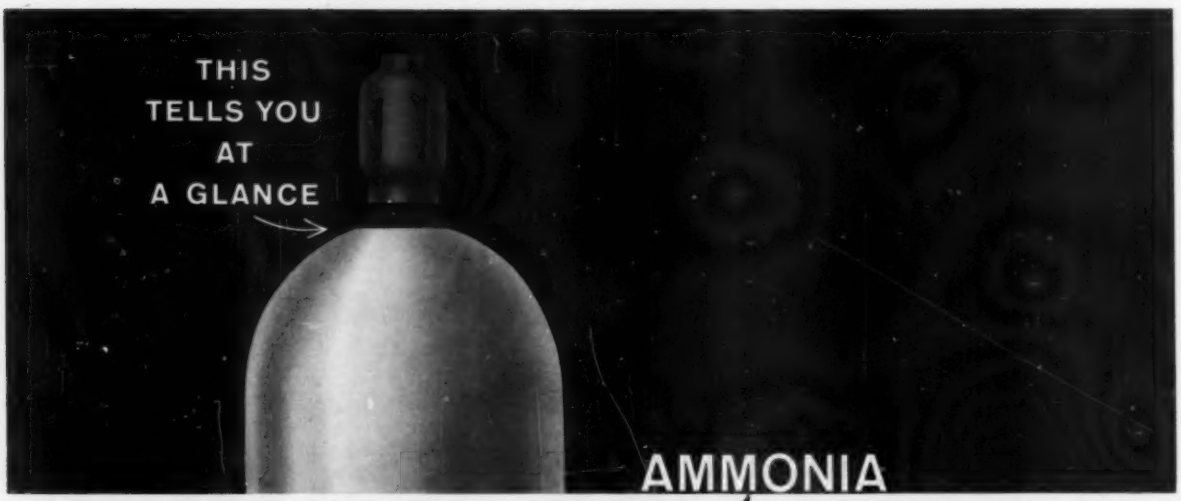


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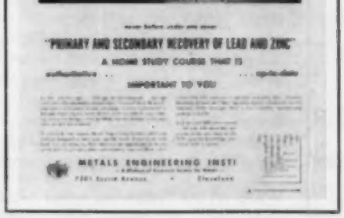


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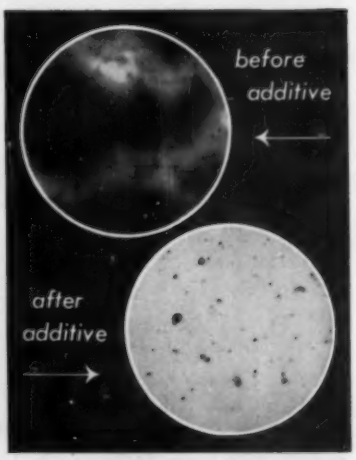


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When melting quality steels or non-ferrous alloys, your melting practice is greatly simplified by using ELECTROMET electrolytic manganese—99.95 per cent pure. You can easily control carbon, phosphorus, and silicon because electrolytic manganese contains less than 100 parts per million of these elements. This is particularly helpful when producing:

• Chromium-nickel stainless steels, especially the chromium-nickel-manganese and extra-low carbon grades. • Low-carbon deep-drawing sheet steels. • High-temperature, non-ferrous, and electrical resistance alloys.

For adding nitrogen and manganese together, 4½ and 6 per cent nitrogen-bearing grades are available. These grades are especially useful when producing free-machining and low-carbon sheet steels. For details, contact your ELECTROMET representative.

ELECTRO METALLURGICAL COMPANY, Division of Union Carbide Corporation, 30 East 42nd Street, New York 17, N. Y.

The thick plate of ELECTROMET electrolytic manganese penetrates the slag and goes into solution rapidly.

**Electromet**

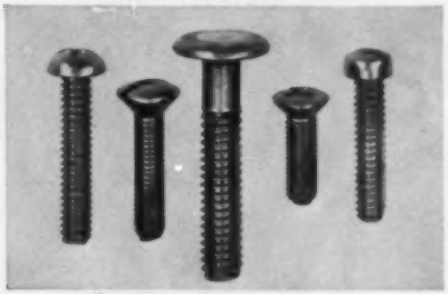
FERRO-ALLOYS AND METALS

UNION CARBIDE

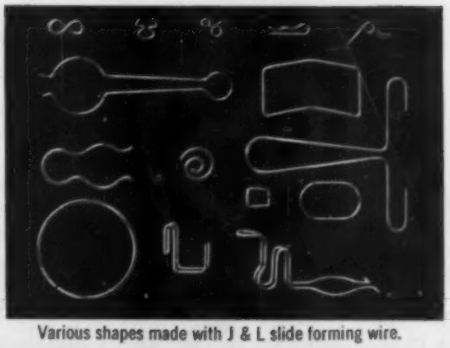
The terms "Electromet" and "Union Carbide" are registered trade-marks of Union Carbide Corporation.

# Quality products start with J&L stainless steel wire

Long-lasting filters and screens are woven from stainless steel wire.



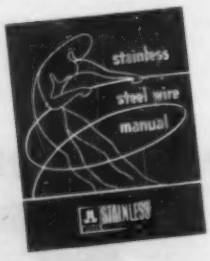
Many types of screws are more economically formed by cold heading.



Various shapes made with J & L slide forming wire.

Many types of products are fabricated from stainless steel wire. We suggest you consider Jones & Laughlin Stainless Steel Wire where ease of forming or special corrosion or heat resisting properties are required.

For *your* particular application or production problem, we offer the services of our stainless steel specialists. A letter or call will receive prompt attention.




Wire today for your copy of J & L's new Stainless Steel Wire Manual.

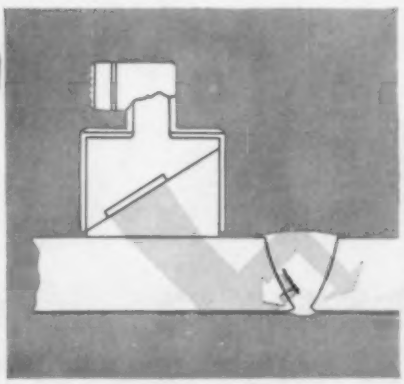
Improve your Products with . . .
J&L STEEL STAINLESS
BAR • WIRE • SHEET • STRIP

**Jones & Laughlin Steel Corporation • STAINLESS STEEL DIVISION • Box 4606, Detroit 34**

MISSILES DEMAND
WELDMENTS OF HIGHEST
QUALITY, REGARDLESS OF COST–

YET LOW-COST
# ULTRASONIC TESTING
IS USED!

This is because Ultrasonic Testing can locate defects in welds that are hidden to other inspection methods.



*Sound beamed at an angle into the plate passes through a good weld but is reflected back from a void.*

WHERE COSTS COUNT MOST
**SPERRY REFLECTOSCOPE**
provides down-to-earth answers on weldment quality for every industry. The Reflectoscope locates cracks, lack of fusion, incomplete penetration, fatigue failure, even in the thickest plate and deepest welds. Costs are low. For example, in a recent test of seam welds on a large pressure vessel, Reflectoscope inspection was one quarter the cost of other testing methods. And, there is no radiation hazard.

FOR INFORMATION ABOUT THIS INSPECTION TOOL, FILL OUT AND MAIL THE COUPON.

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The Show That MEANS

# ...Business in the West!

# Western Metal Show

## PAN-PACIFIC AUDITORIUM • LOS ANGELES

## MARCH 16-20, 1959

During the past quarter-century of flourishing growth of industry in the West, one exposition pioneered and grew with this record-breaking western progress — the Western Metal Show.

Continuing to keep pace with these great western industrial markets, the 11th Western Metal Show will open next March 16 in Pan-Pacific Auditorium. Hundreds of the nation's leading firms will go west once again to present their metals, their equipment, their processes and their improved and new products.

This great metals week of the West will not only present what's new and improved . . . it will be a proving ground for scores of new developments presented in technical and practical engineering sessions sponsored by the American Society for Metals and 20 cooperating societies and associations. Thousands of metal men will have every reason to attend this outstanding event.

Floor plans for this 11th western show are now available. Make certain you have your copy . . . that you select your exhibit space . . . that you make your plans to exhibit in the show that will *mean business for you* in the West.

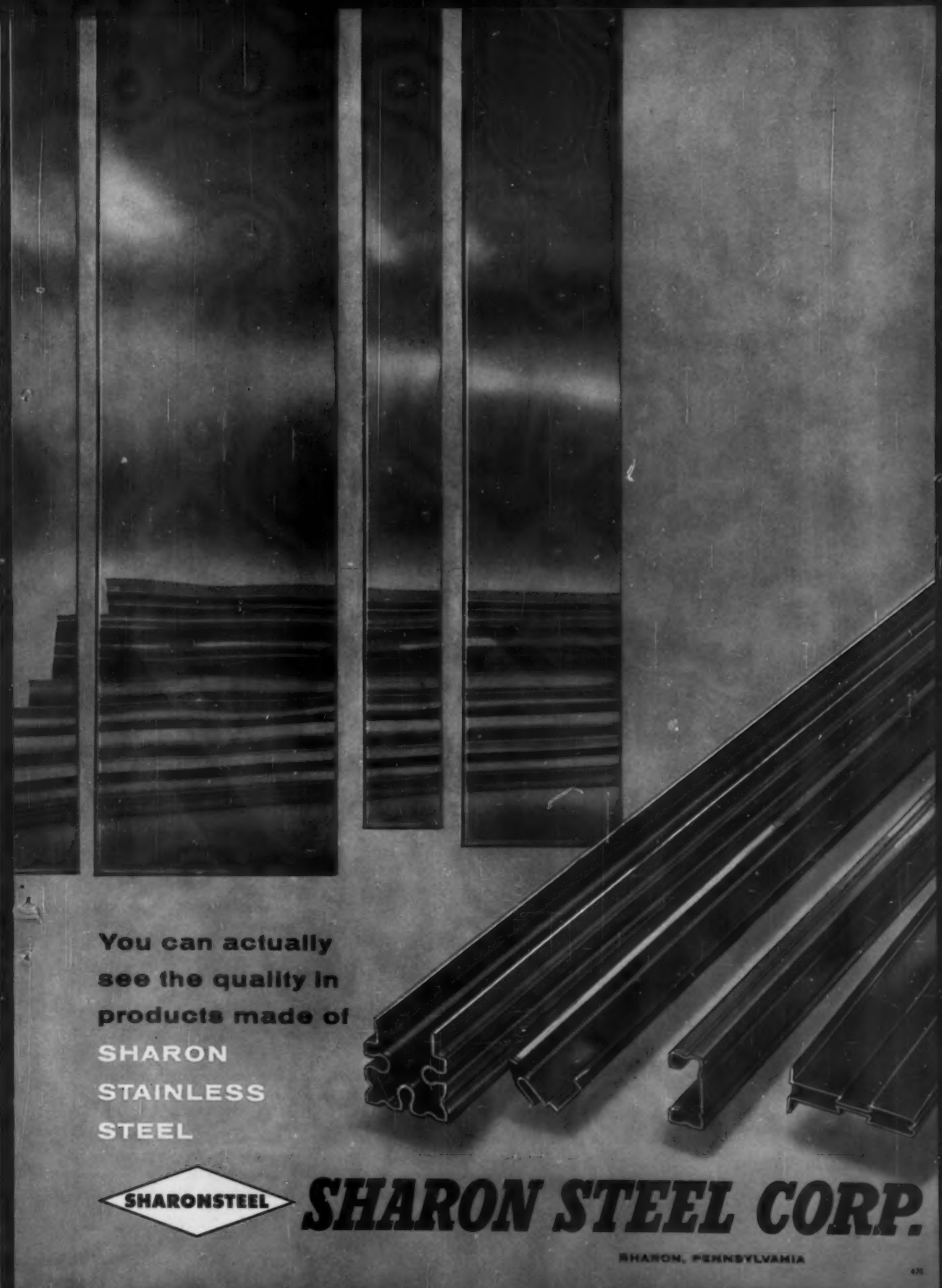
• • •

**WESTERN METAL CONGRESS & EXPOSITION**

*Owned and Operated by the*

**AMERICAN SOCIETY FOR METALS**

7301 Euclid Avenue • Cleveland 3, Ohio


You can actually
see the quality in
products made of
SHARON
STAINLESS
STEEL
SHARONSTEEL
SHARON STEEL CORP.
SHARON, PENNSYLVANIA

# Zinc + Die Casting

## ELIMINATES MULTIPLE-PIECE ASSEMBLY

The one-piece housing of this electrically-driven, extendable-rod type radio antenna is designed to hold all the drive components. Manufactured by The Pioneer Specialty Company, Detroit, it also provides the means of attaching the motor and the main tube to the mast assembly.

Use of zinc for the housing provides maximum corrosion resistance without additional finishing. Due to the high fluidity of zinc alloys at casting temperature, die castings of highly complex design needing little or no machining can readily be produced. Of all the metals commonly used in die casting, zinc alloys rate highest in dimensional accuracy. Since tolerance within the gear centers of the housing had to be held to ± .002, the selection of zinc for this application was based on the superior properties inherent in the metal.

**OVER 5,000,000* RADIO LISTENERS ARE ON WHEELS**

To get extra mileage from this vast audience the Mutual Broadcasting System has set up an experimental "auto network" of 31 stations stretching from Buffalo to Miami. Purpose: frequent weather announcements plus advice not only on the best routes but on what local station to tune in for news of conditions on the next leg of a long drive north or south. If the new scheme works out, Mutual plans to extend it to all 450 network affiliates.

*National Average Day, 7 A.M.-10 A.M.

*DIE CASTING is the Process... ZINC, the Metal*
...BUNKER HILL, the Preferred Zinc

## BUNKER HILL 99.99+% ZINC

EASTERN SALES AGENTS:
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# DREVER

## Plate

### Heat Treating Line

Shown is the charging end of a 145'-0" hardening furnace. In the background can be seen a 2500 ton pressure quench, 200'-0" draw furnace and the operator's control pulpit.

This roller-hearth plate heat treating line, known to be the largest of its type, has a capacity to treat plate up to 21-1/2 tons per hour. The equipment is capable of handling plate sizes up to 175" wide x 3" thick x 600" long.

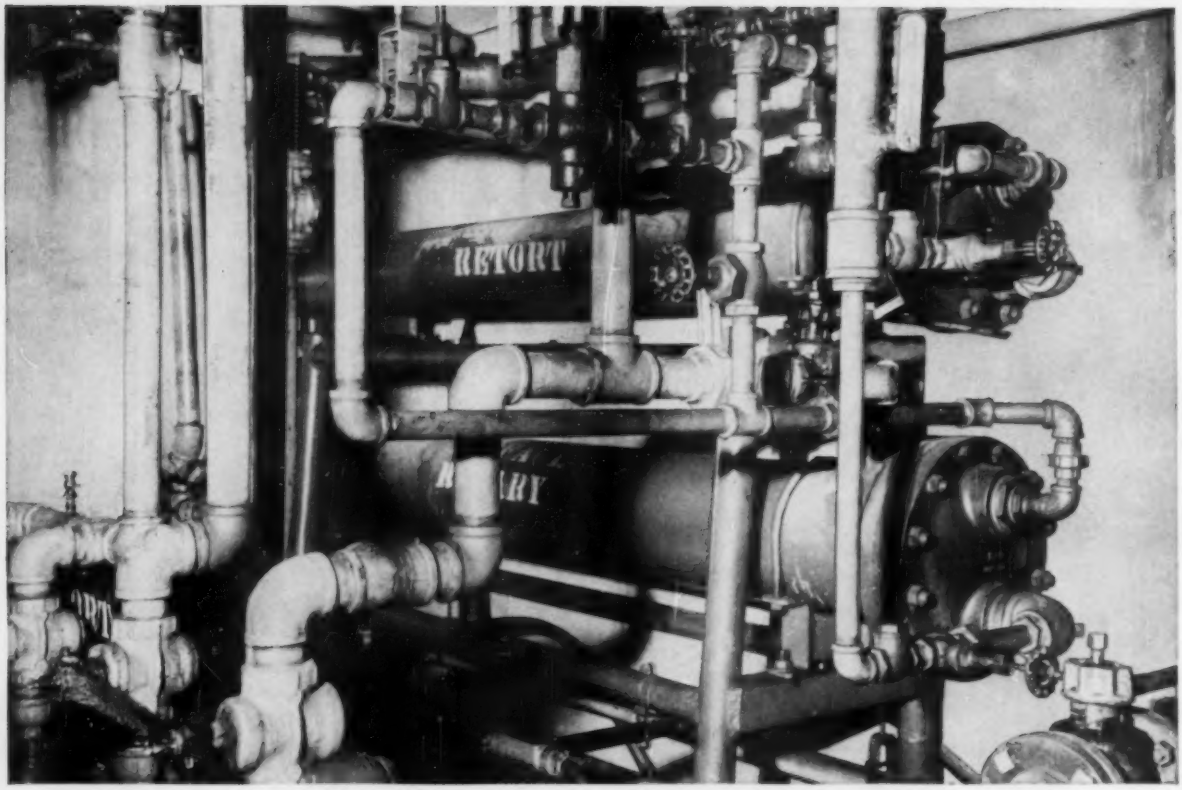
The furnace rolls are 25/12 modified alloy and are designed for a maximum furnace operating temperature of 1650° F.

The maximum fuel capacity for both furnaces is 122,000,000 Btu's per hour.

The entire line is under the control of a single operator. Full utilization of strategically located TV cameras enables the operator to have full control over all operations.

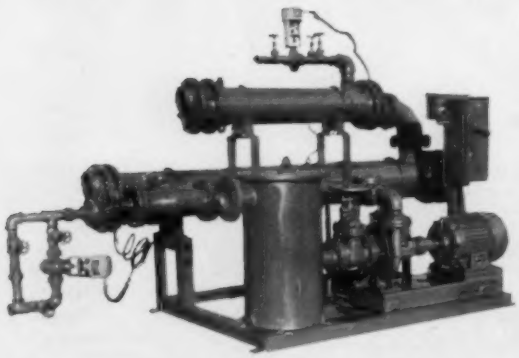
DREVER COMPANY

RED LION ROAD and PHILMONT AVE., HUNTINGDON VALLEY, PA.




# B&G *Controlled* QUENCH OIL COOLING

## helps CHRYSLER maintain uniform quality of heat treated parts



**COMPLETELY SELF-CONTAINED UNITS**

B&G *Hydro-Flo* Self-Contained Oil Coolers combine Coolers, Motors, Strainers and all controls into single, integrated units. Fully automatic, they keep oil temperature at the desired degree through all stages of the quench. Your only responsibility is to connect to the quench tank and water lines. Units can be easily moved if ever necessary.

*This combined Catalog and Selection Manual gives full information on B&G Self-Contained Oil Coolers. Send for your copy.*

In the Chrysler Automatic Transmission Plant at Indianapolis, Indiana, holding uniform quality of heat-treated parts is aided by *controlled* quenching with B&G oil cooling equipment.

A B&G *Hydro-Flo* Oil Cooling System eliminates the warping and quality variations caused by uncontrolled quenching. The oil in the quench tank is kept constantly at whatever temperature is desired and at maximum turbulence. Each group of parts passing through the operation is processed under identical conditions, thus insuring consistent quality.

B&G Oil Cooling Systems may be purchased as complete "packages" or as component parts for assembly on the job. B&G Quench Tanks are also available—either in standard designs or built to your specifications.

The B&G engineering department is always at your service.

B&G

**Hydro-Flo***

**OIL QUENCHING SYSTEMS**

*Reg. U.S. Pat. Off.

**BELL & GOSSETT COMPANY**

**Dept. FI-16. Morton Grove, Illinois**

*Canadian Licensee: S. A. Armstrong Ltd., 1400 O'Connor Drive, Toronto 16*

# Tool Steel Topics

BETHLEHEM STEEL COMPANY, BETHLEHEM, PA.


# Lustre-Die held costs down in molding plastic covers

"We need," said the customer, "a plastic cover to protect our sealed motors. It's to be drip-proof and sturdy, yet must be a low cost item. Do you have a grade of die steel which will help us produce such a cover economically?"

The mold maker, Dollins Tool & Gage Co., Independence, Mo., put the problem up to Ford Steel Co., St. Louis, our local tool steel distributor. Quick as a flash came their recommendation: "Lustre-Die!"

The electric-furnace steel performed to everyone's satisfaction. It was economical. It took a high polish. It had high compressive strength. It machined easily. It performed well in molding the parts which were held to a close tolerance of .001 in.

Lustre-Die is just the ticket for molding plastics because its properties make possible a bright, mirror-like polish. Lustre-Die has the proper basic analysis for molding plastics. And it offers something more — alloy fortification! Lustre-Die is heat-treated by oil-quenching and tempering to augment its properties, and is furnished ready for machining and polishing.

Lustre-Die is carefully inspected to insure cleanliness. It is free from injurious porosity or surface pitting. And there's no problem about inclusion-causing additions.

Lustre-Die is a good steel to keep in mind for your next plastic-molding operation. Your Bethlehem tool steel distributor can furnish it from stock. Why not give him a call?

## BETHLEHEM TOOL STEEL ENGINEER SAYS:

### *Here's Why Air-Hardening Steels are Good Performers*

When a large group of various types of tools made from air-hardening tool steels is compared with a group of similar tools made from steels which require liquid quenching for hardening, it will be found that the air-hardened tools outperform the liquid-quenched tools in service. This result will not necessarily be found in the comparison of individual tools, but will appear if a large enough variety and number of tools are studied.

The reason why air-hardened tools outperform liquid-quenched tools can be summed up in one word — consistency. The consistent performance of air-hardened tools is evident in many ways:

#### DIMENSIONAL STABILITY

All tools, when subjected to the hardening operation, develop small but measurable dimensional changes (so-called distortion). Air-hardened tools not only show less dimensional change than liquid-quenched tools, but the changes that do occur are remarkably similar in each tool when identical tools are made up. By contrast, liquid-hardened tools show considerably more variation from tool to tool when identical tools are produced.

#### HARDNESS

Duplicate air-hardened tools invariably show the same hardness after heat-treatment. Liquid-quenched tools may show erratic hardness in various locations on a tool, due to variations in effectiveness of the liquid quench; however, duplicate tools will each have a somewhat different hardness pattern.

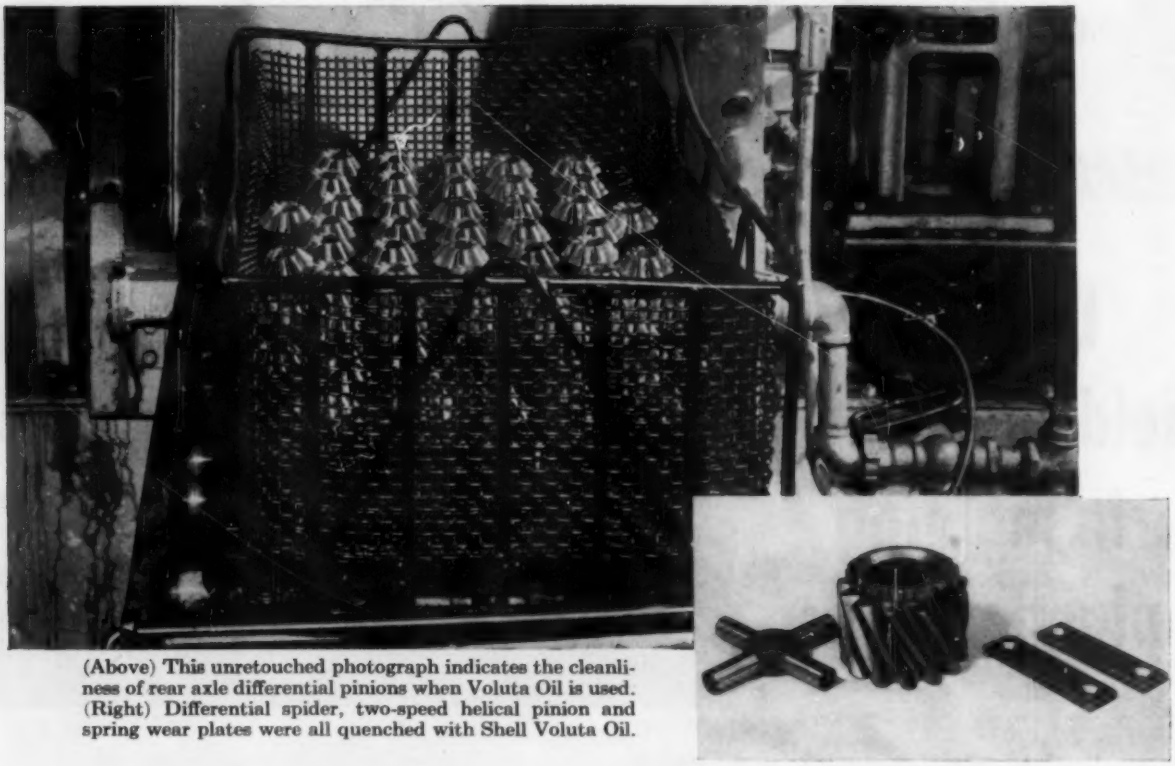
#### RESIDUAL QUENCHING STRESSES

All tools develop residual internal stresses due to the hardening operation. Liquid-quenched tools develop high internal residual stresses because of the variations in cooling rate which occur in different locations on a tool during the quench. If improperly controlled, these stresses can lead to cracking of the tools in heat-treatment or in grinding, or the load-carrying ability of the tools may be low and erratic.

By contrast, air-hardened tools develop only a low degree of internal stress during hardening, because of the comparatively uniform cooling in the quench. Furthermore, the degree of internal stress which develops is uniform from tool to tool, so that the service performance of duplicate tools is reasonably consistent.

The advantages of air-hardening steels cannot be realized, however, unless they are hardened by air-quenching. It is possible to harden all air-hardening steels by liquid-quenching (oil-quench or salt-quench as in martempering) and this is frequently done because of the convenience of existing heat-treatment equipment. However, liquid-quenching of air-hardening steels is a serious mistake, because it sacrifices almost all the basic advantages of air-hardening steels. Liquid-quenching not only increases distortion and internal stresses, but may lead to cracking of some of the tools during heat-treatment. Air-hardened steels which are properly quenched in air do not crack in heat-treatment.

Bethlehem offers a full range of air-hardening steels: Bearcat for shock applications, A-H5 for general-purpose tool and die work, and Lehigh H for maximum production runs.



(Above) This unretouched photograph indicates the cleanliness of rear axle differential pinions when Voluta Oil is used. (Right) Differential spider, two-speed helical pinion and spring wear plates were all quenched with Shell Voluta Oil.

# Here's a stable, high-speed quenching oil that minimizes work distortion

There has long been an urgent need for a uniformly stable quenching oil that would perform satisfactorily with minimum distortion of the workpiece. During the quenching operation, fluid deterioration can occur, causing sludge and acid formations which in turn result in non-uniform physical characteristics of quenched parts.

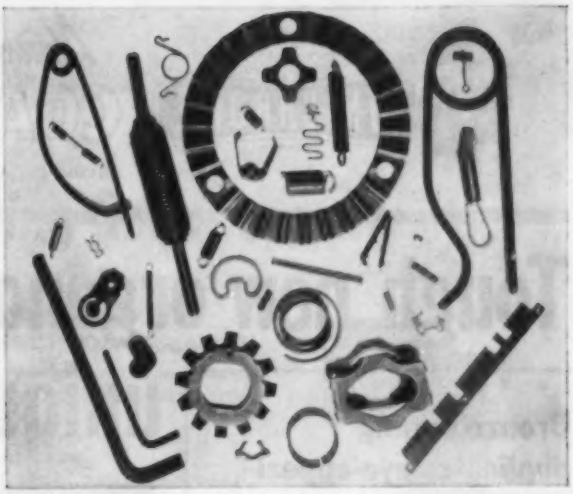
An efficient and timely answer to this industry problem is found in Shell Voluta Oils. They satisfy the two basic requirements of a high-quality quenching oil: 1) They remain stable at temperatures much higher than heretofore allowable, with no appreciable sludge formation. 2) They permit safe, rapid quenching of parts which have a tendency to distort. This is in part due to the higher permissible fluid temperatures, and also to the greatly enhanced wetting qualities of Voluta* Oils.

There are many applications that clearly demonstrate the efficiency and versatility of Voluta Oils.

One example relates to a leading producer of several thousand varieties of axle parts. With conventional quench oils, rejects were high due to unfavorable stress concentration and subsequent cracking. After changing to Voluta Oil, maximum uniformity was achieved because of Voluta's superior wetting-out properties and stable cooling rate. For heat-treating purposes, Voluta Oils proved stable at temperatures from 130° to 200° F. They also provided greater surface hardness, depth of hardness and uniformity.

A well-known manufacturer of automotive steering units was faced with a similar situation. Here the problem involved heat-treating low-carbon-steel parts as well as grey-iron castings. Although they were of widely varying materials, shapes and sizes, this company found that

Shaker hearth furnace automatically dumps parts into Shell Voluta Oil, then removes and drains them.



Over 35,000 prints of production items like these (quenched in Voluta Oil) are kept on file by one leading steel spring manufacturer.

Voluta Oil was far superior in all these ways: 1) longer life; 2) clean, scale-free parts; 3) wider range of quench temperatures; 4) no rejects due to distortion; 5) no sludge formation.

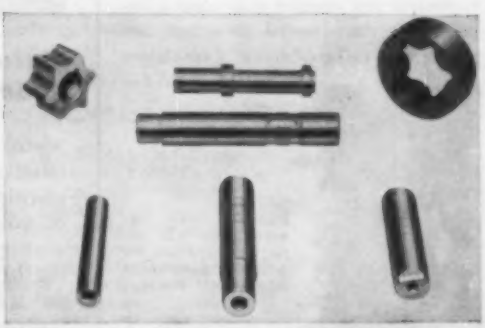
Still another case occurred during the manufacture of many thousands of different shaped springs. This company wanted to insure maximum elasticity of their springs, and to achieve this a 100 per cent martensitic structure had to be maintained. Tested in competition with several other quench oils, Shell Voluta Oil again proved superior because it resulted in the production of distortion-free springs, and allowed quicker drainage and minimum dragout loss.

Another feature: Voluta affords substantial savings on a yearly basis . . . and it further proves its economy in reduction of rejected parts.

Perhaps you have a similar quench problem . . . or any quench problem, for that matter. It would be to your advantage to call or write your nearest Shell Oil office. We'd be glad to have our representative discuss your particular quench problem and methods to help overcome it.

*Registered Trademark

Parts are heat-treated and quenched in two-zone hardening furnace while Voluta Oil's temperature is closely controlled.



Castings and low-carbon-steel parts for hydraulic steering units are all processed through the same heat-treating furnaces and quench tanks.

**SHELL OIL COMPANY**

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*News about*

# COATINGS for METALS

*Metallic.....Organic.....Decorative.....Protective*

# Tough new organosol coating sprays unique textured finish

## Bronze plating duplicates eye-appeal of 24K gold finish

A copper-tin plate with the rich, brilliant appearance of 24K gold is easily obtained from the unique M&T Bronze plating process.

**CORROSION RESISTANT, TOO**

This most attractive decorative plate offers excellent corrosion protection for the product. Coated with a clear lacquer, it provides a high quality finish with long life as well as unusual appeal. It lends itself to distinctive accent applications, or to a uniform overall finish even on parts with complicated shapes.

M&T Bronze deposits as an 88% copper – 12% tin alloy. It covers recessed areas uniformly. Since the process is as easy to control and operate as processes depositing a single metal, designers can specify it in full confidence of consistent results. Send for more data.

Die cast trophies formerly plated with copper, nickel and gold now get equally handsome gold-like M&T Bronze.

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**CORPORATION**

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### *Outwears textured baked enamels by 10 to 1*

Metal & Thermit presents UNICHROME COATING 6400, latest addition to a comprehensive line of vinyl dispersion finishes. This coating offers two advantages that set it apart as an extraordinary finish for quality products such as business machines, office furniture and similar items.

(1) It has an interesting and rich texture akin to high cost grained leather. (2) It has been endowed with properties that enable a COATING 6400 finish to retain its eye appeal long after lesser finishes have deteriorated or failed.

**PROMOTING LONG LIFE**

A new type of organosol formulation, COATING 6400 has the well known chemical resistance of vinyl coatings to acids, alkalies, moisture, salt solutions and other causes of finish failure and corrosion.

It is a hard yet flexible coating . . . surpassing normal textured enamels in resistance to handling and abusive service conditions by as much as 10 to 1. *Applied by spraying*, it builds films of 8 to 40 mils, depending on the number of coats. COATING 6400 sticks tight to properly primed metals, will not chip upon impact.

Other features: Excellent electrical insulating qualities; gloss which can be varied from high to matte; wide selection of colors.

Write Metal & Thermit for detailed information on UNICHROME COATING 6400.

*Unichrome is a trademark of Metal & Thermit Corp.*

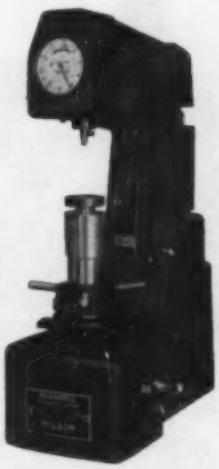
# WILSON "ROCKWELL"

HARDNESS TESTERS • *WORLD'S STANDARD OF ACCURACY*

ACCO for Better Values

# Equipment for *EVERY Hardness Testing Requirement*

## WILSON "ROCKWELL" HARDNESS TESTERS ... ACCURATE AS A PRECISION BALANCE



No matter what your hardness testing requirements are, there's a WILSON "ROCKWELL" instrument to do the job. Choose from this complete selection of hardness testers:
*"ROCKWELL"*—for most hardness testing functions.
*Superficial*—for extremely shallow indentations.
*Twintester*—combines functions of "ROCKWELL" and "ROCKWELL" Superficial testers.
*Semi-Automatic (manual feed) and Fully Automatic*—for automatically classifying tested pieces as CORRECT, TOO HARD, or TOO SOFT—at test rates up to 1000 pieces per hour.
*Special Machines*—for testing large objects, obtaining internal readings, and other unusual applications.

**ALL WILSON "ROCKWELL" hardness testers provide these advantages:**
*Accurate performance*—precision built, with exact calibration, for consistently correct results.
*Long life*—durable as a machine tool.
*Easy operation*—even an unskilled operator can get perfect readings. All controls conveniently grouped.
*Easy maintenance*—interchangeable mechanisms, with spindles mounted on oil-less bearings.

## DIAMOND "BRALE" PENETRATORS ... perfect testing every time

A perfect diamond penetrator is essential to accurate hardness testing. Since one point of hardness on the "ROCKWELL" scale represents only 80 millionths of an inch penetration—only 40 millionths on a Superficial tester—the slightest imperfection will cause a false reading.

Only *perfect* Wilson Diamond Brale Penetrators are sold. Each diamond is flawless, with no chips or cracks. It's cut to an exact shape. Microscopic inspection of every diamond—one at a time—assures this perfection—and assures you of accurate hardness testing every time.

## TUKON TESTER ... for precision MICRO & MACRO testing

The TUKON Tester measures extremely shallow indentations. It's used, for instance, by manufacturers of watches, hairsprings, needles, and fine wire. Laboratories use the TUKON for tests on individual crystals or particles of microscopic size. Producers of coatings, film, ceramics, and many other materials have made good use of the TUKON.

Three models are available to meet your individual requirements. TUKON Testers use both the Knoop and 136° Diamond Pyramid Indenter. Each TUKON Tester is a self-contained hardness testing instrument— no accessory equipment is needed. Knife edges and levers of fixed length are used throughout for application of exact load and freedom from internal friction.

## A COMPLETE LIBRARY of helpful information

A wide variety of bulletins describes the many instruments, accessories, and services Wilson offers. Write for your choice:

**DH-325**— WILSON "ROCKWELL" Hardness Testers • **DH-326**—"ROCKWELL" Superficial Hardness Testers • **TT-58**—"ROCKWELL" Twintester • **DH-327**—Special "ROCKWELL" Testers, including Automatic and Semi-Automatic models • **DH-7**—TUKON Applications • **DH-328**—TUKON Testers.

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MECHANICAL INSTRUMENT DIVISION
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*Accommodates complete*

# CREEP RECORDING INSTRUMENTATION

*together with*

# *VACUUM FURNACE*

Creep and stress rupture testing of materials at temperatures to 2000° F., in vacuums to 1 x $10^{-5}$ mm Hg, can be performed on the Riehle creep testing machine when equipped with a recently developed vacuum furnace. Creep measuring equipment employing electronic recording of specimen strain is provided.

Programmed tests for both creep and relaxation and under vacuum furnace conditions may also be made on the Riehle Universal Testing machines of any capacity with equipment and instruments available.

Convenience in observation and operation is assured because both the elevated temperature equipment and recording instrumentation are designed to function as an integral part of the Riehle machine.

**Other Riehle Testing Machines:** *Hydraulic and Screw Power Universal Testing Machines, Hydraulic Fatigue Testing Machines, Construction Materials, Impact, Brinell, Torsion, Horizontal Chain, Rope and Cable Testers, Portable Hardness Testers for Rockwell Readings, Etc.*

***Free Bulletin . . . Mail Coupon***

**Riehle TESTING MACHINES**

A DIVISION OF

American Machine and Metals, Inc.

EAST MOLINE, ILLINOIS

"One test is worth a thousand expert opinions"

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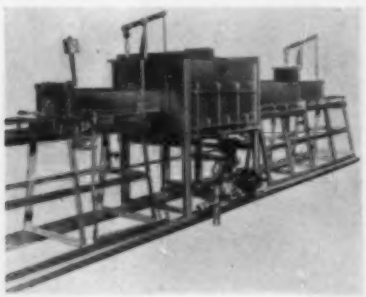
# APPLICATION and EQUIPMENT new products

## *Furnaces*

The American Gas Furnace Co. has announced a new line of hydrogen-atmosphere muffle furnaces for operation at temperatures from 1150 to 2100° F. for the bright brazing, annealing and hardening of stainless steel parts. They may also be used for



silver soldering and annealing of ferrous, nonferrous or precious metals. The work is placed in alloy baskets and pushed through the purging, heating and water-jacketed cooling sections of the furnace. The furnace can handle large or unusually shaped pieces because of its D-shaped muffle construction. Burners fire both top and bottom into both sides of the heating chamber.

**For further information circle No. 1 on literature request card, page 48-B.**

## *Bronze*

A corrosion-resistant nickel-silicon bronze alloy combining both high yield strength and high ultimate tensile strength even at elevated temperatures has been announced by Chase Brass & Copper Co. It is age hardenable and is available in soft, cold forming, and hard tempers. Age hardening of the alloy is by treatment at 900°F. for 90 min. Electrical conductivity is 36% in a fully heat treated bar. The new alloy is composed of 97.5% Cu, 1.9% Ni, and 0.6% Si.

**For further information circle No. 2 on literature request card, page 48-B.**

## *Hot Hardness Tester*

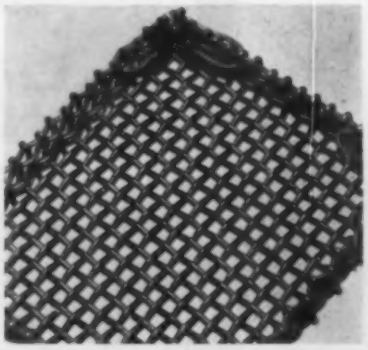
Hot hardness testing, utilizing a Rockwell tester in conjunction with a small electric furnace, has been announced by the Wilson Mechanical Instrument Div. The device can be used to determine the Rockwell hardness of metals contained within the shell of a controlled atmosphere gas furnace at temperatures exceeding 1500° F. The test specimen is heated to a predetermined temperature in a small electric furnace which utilizes a controlled atmosphere inert gas. The tester's diamond Brale penetrator is contained within the furnace and is heated along with the specimen under test. Hardness tests are conducted in the usual manner. For temperatures to 1200° F., the furnace operates on 110 volts, single-phase power with a maximum input of 1500 watts. For 1500° F. op-

eration, the furnace would operate on 80-volt, 60-cycle, single-phase current. A variable voltage transformer is used to permit precise control of input voltage.

**For further information circle No. 3 on literature request card, page 48-B.**

## *Sintering Trays*

The Cambridge Wire Cloth Co. has announced a wire-cloth tray for the sintering and heat treating of powdered metal parts and other metal products. A wire clip is inserted around each corner to prevent failure there. This wire clip starts at the inside corner, extends along the inside of the tray for about 2 in., then runs through to the outside of the tray, back around the corner and through to the inside of the tray again. The ends



are then welded at the inside corner. The clip has also been designed to allow for heat expansion.

**For further information circle No. 4 on literature request card, page 48-B.**

## *Platinum Plating*

A new platinum plating process for high-temperature and other industrial applications has been anounced by the Precious Metals Div. of Sel-Rex Corp. Platinex produces a fine-grained platinum electroplate, in any practical thickness, directly from the bath in one continuous operation. The platinum electroplate is able to withstand 2000° F. indefinitely. Electroformed sheets can be formed or even crimped without cracking because of the low stress and high ductility features of the process. The bath, which requires only the addition of a replenisher and water for maintenance, operates at 165 to 185° F.

**For further information circle No. 5 on literature request card, page 48-B.**

## *Aluminum Tubing*

Seamless aluminum tubing redrawn to wall thicknesses of 0.010 to 0.002 in. on ¼ to ⅝ in. o.d.'s has been announced by H & H Machine Co. The tubing comes in lengths up to 5 ft. It can be cut to specified lengths and fabricated, if desired. Small parts (up to 12 in.) can be given an anodized coating for corrosion resistance or electrical insulation. Anodized coating can be dyed blue, violet, red, copper, or gold. Tubing is available in high-purity aluminum (99.8% with 0.015%

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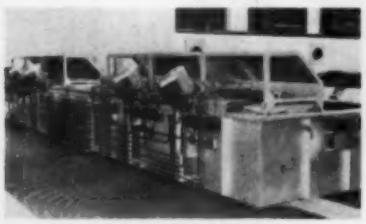
maximum iron content) or in 2S or 52S aluminum.

**For further information circle No. 6 on literature request card, page 48-B.**

### *Pickling*

A molten salt bath tank, with a work area 42 by 5 by 6 ft., part of a seven-tank pickling line operating at the Huntington, W. Va., works of International Nickel Co., has been announced by Kolene, Inc. Kolene's No. 1 oxidizing salt is used in Tank No. 1 (illustrated), for descaling, degreasing and deglassing of tubes, rods, shapes, wire and strip. The chemical structure of nickel-chromium scale is

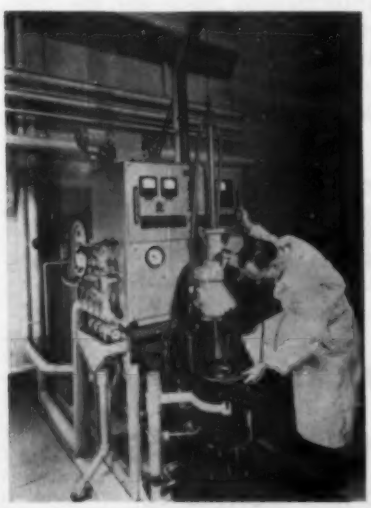


changed in the molten salt so that subsequent acid baths remove these impurities. A high proportion of oxidizing agents results in bath stability even during the degreasing operation. Carbonates and insolubles settle out into a sludge collection zone outside the work area. Twenty-four gas-fired immersion tubes maintain the bath at 900° F., while four mechanical agitators insure uniform heat transfer throughout the bath.

**For further information circle No. 7 on literature request card, page 48-B.**

### *Vacuum Arc Furnace*

A vacuum arc furnace for pilot plant or small-scale production of pure melts of metals and alloys with high-melting temperatures has been announced by the Rochester Div. of Consolidated

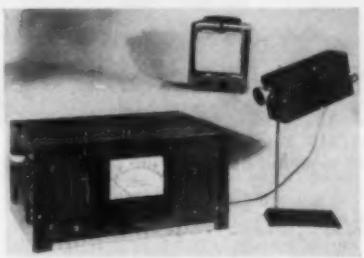


Electrodynamics Corp. The furnace is rated at 3000 amp. maximum, and handles melts from buttons to 40-lb. ingots of titanium or 70-lb. ingots of steel. Five interchangeable crucibles are included. Fixed electrodes of tungsten or metallic carbides, or consumable electrodes of the metal being melted, may be used. Consumable electrodes up to 4½ in. in diameter and 19 in. long are fed automatically. A mechanical pump pulls down the furnace from atmospheric pressure to 1 micron in 40 sec.

**For further information circle No. 8 on literature request card, page 48-B.**

### *Temperature Measurement*

A new type instrument which will measure the temperature of any solid, liquid or luminous flame in the 1500 to 4000° F. range without making emissivity corrections, has been announced by Shaw Instrument Corp. This radiation ratio pyrometer consists of two units—a sensing head for detecting radiation, and a control unit which interprets the information.



Temperature is indicated on a 7-in. meter calibrated in degrees. A 0 to 100 millivolt output is provided for operating a strip chart recorder or controller.

**For further information circle No. 9 on literature request card, page 48-B.**

### *Cadmium Plating*

Allied Research Products has announced the introduction of Iridite 4P-4, a powder which permits a single dip process for chemically brightening and protecting cadmium plated surfaces. It requires no bleach and may be used in either rack or bulk work.

**For further information circle No. 10 on literature request card, page 48-B.**

### *Heaters*

Hevi-Duty Electric Co. has announced a line of flat and semi-cylindrical electric heating units in many sizes and two temperature ranges, 1800 and 2200° F. maximum. Flat units may be used as a flat heating surface or may be grouped together to form an enclosed heating chamber. The refractories are shaped so that the electric coils may be either exposed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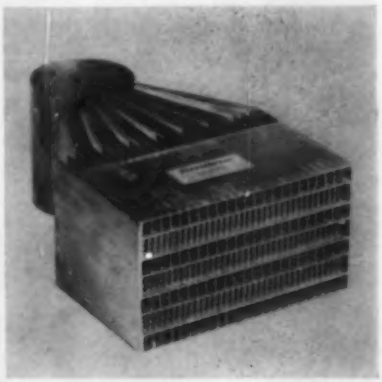

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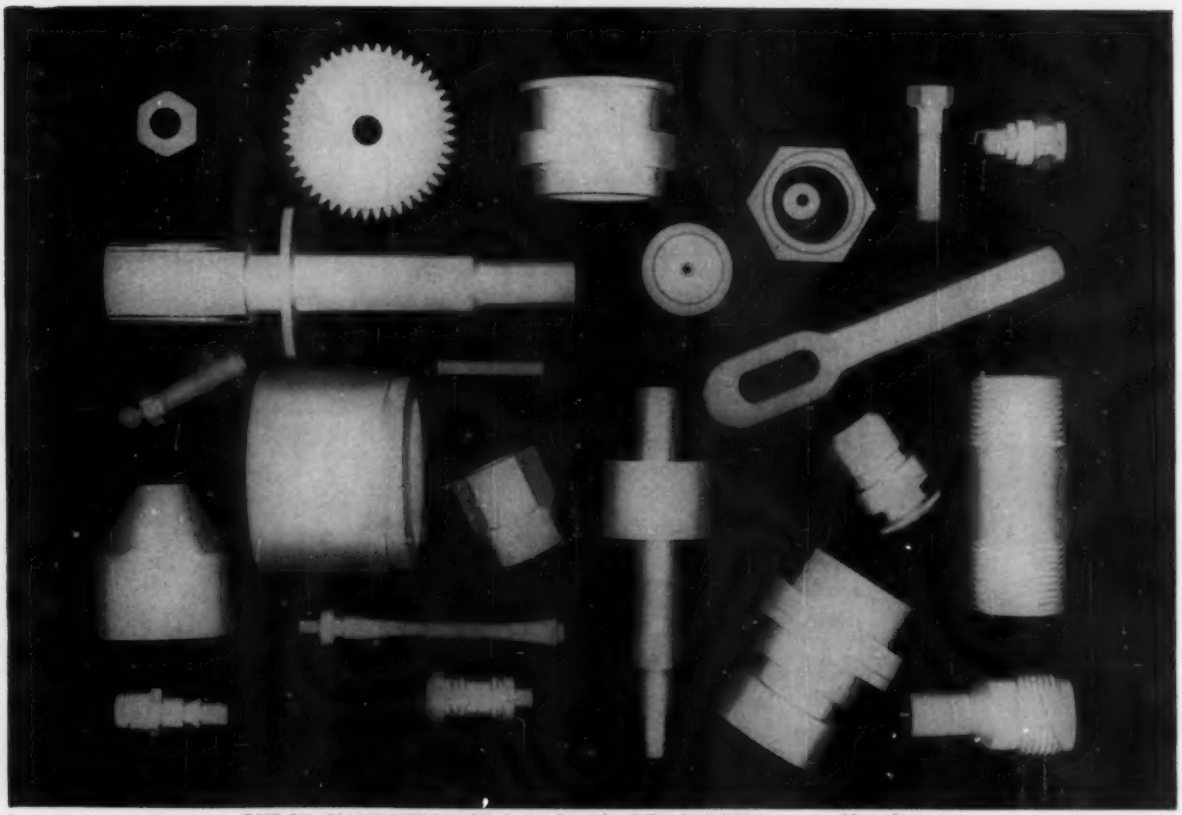

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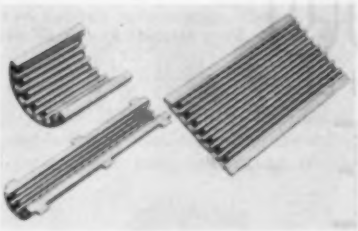
or muffled, depending upon the nature of the material being heated. Semi-cylindrical units are used for heating straight lengths of pipe or tubing.



They can be arranged to completely surround a pipe, or to apply heat under a curved surface. These units are available in 29 standard sizes.

**For further information circle No. 11 on literature request card, page 48-B.**

### *Metal Finishing*

The Roto-Finish Co. has announced a new machine designed primarily for deburring, which may be used for polishing and surface improvement, microfinishing of the order of 3 to 4 rms., and stress relieving. Deburring and polishing can be done on the inside diameters of parts, such as inside

gears and hydraulic pistons. The standard machines are equipped with 4, 8, or 16 spindles and time cycles range from a few seconds to 6 min. Based on one part fixtured to a spindle, a 16-spindle machine operating on a 4-min. cycle would produce a minimum of 240 completed pieces per hour.

**For further information circle No. 12 on literature request card, page 48-B.**

### *Textured Aluminum*

Textured-finish aluminum sheet has been announced by Reynolds Metals Co. The product has a surface similar to sanded sheet. The uniform mat surface helps conceal scratches and other minor surface abrasions. The sheet is available in all standard sizes.

**For further information circle No. 13 on literature request card, page 48-B.**

### *Potentiometer*

A new indicating version of the Dynamaster self-balancing electronic potentiometer or bridge has just been announced by the Bristol Co. This new indicator is designed for use when legibility of the indicating scale from greater distances is an important factor. The instrument has the same 32 in. long scale and the same pointer as the standard round-chart recording Dynamaster, and is mounted in a standard case. There is no recording mechanism, however. It can be used for measurements of such variables as temperature, speed, pressure, smoke density, pH, and electrical values.

**For further information circle No. 14 on literature request card, page 48-B.**

### *Electrical Steel*

A new electrical steel for use in high-frequency equipment has been announced by Allegheny Ludlum Steel Corp. The new product is called 0.004-in. gage Silectron special grade strip. It is designed for high-frequency applications where high permeability and low exciting current are essential at high inductions. The new strip is a C-10 coated, cold rolled oriented strip with best magnetic properties parallel to the rolling direction. After fabrication it is given a special stress relief anneal in a nonoxidizing, noncarburizing gas atmosphere.

**For further information circle No. 15 on literature request card, page 48-B.**

### *Recorder*

A new small strip-chart recorder has been announced by Rust Industrial Co. Scale length is 2 5/16 in. The pointer swings free most of the time, recording against special pressure-sensitive paper once every 2 sec. This action generates a continuous line formed of small dots A 63-ft. paper roll is designed for the Rustrak recorder and it yields a month's continuous logging

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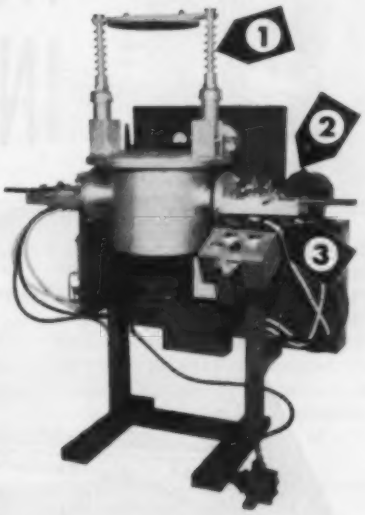


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# Udimet 500

a vacuum induction melted alloy

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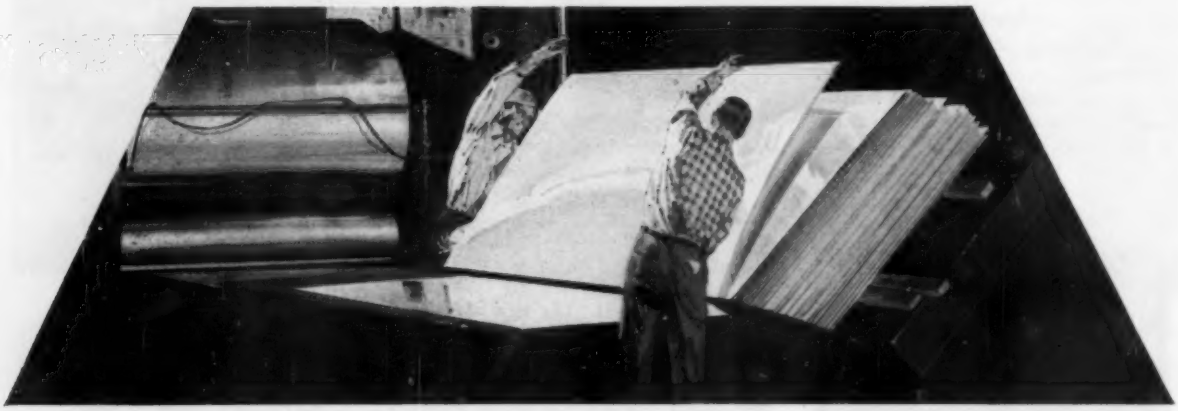

Udimet 500, a superior alloy proven by extensive high temperature applications, is now available in sheet in production quantities for early delivery. It is produced in widths to 48″ by 144″ in length and in thickness down to .010″. The alloy combines very high stress rupture life with excellent ductility and fatigue resistance in the 1200°F to 1800°F ranges.

Many other vacuum induction melted alloys are also now marketed in sheet form by the Utica Metals Division.

New alloys are being developed at Utica for critical sheet application. We are interested in discussing uses for our sheet material where high tensile strength, corrosion resistance, high stress rupture life and electrical or magnetic properties are critical requirements.

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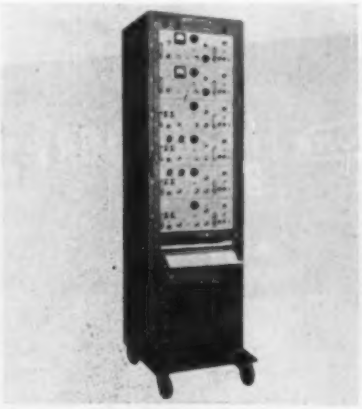
(1 in. per hr.). Interchangeable gear train inserts are also available for logging at higher speeds, up to 30 in. per hour. The recorder weighs 3½ lb. and is 3⅝ by 5⅝ by 4⅛ in. in size.

**For further information circle No. 16 on literature request card, page 48-B.**

### *Recorder*

A new cabinet for its 6-channel direct-writing oscillographic recording systems has been announced by the



Sanborn Co. A mobile cabinet contains the basic assembly, comprised of six driver amplifier-power supply units and recorder assembly. To complete the system, the user adds any of 12 plug-in preamplifiers. Overall dimensions of the cabinet are 78 in. high by 22 in. wide by 25 in. deep.

**For further information circle No. 17 on literature request card, page 48-B.**

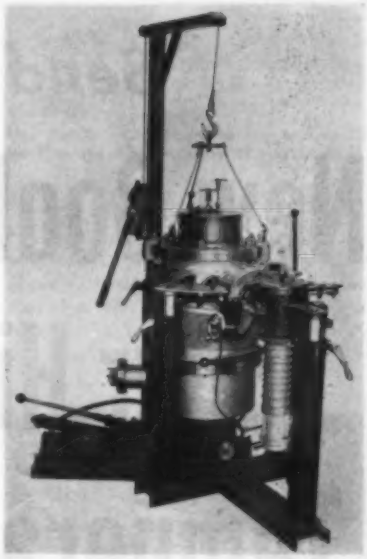
### *Compression Testing*

A hydraulic testing fixture for quick comparative checks has been announced by Haller, Inc. A part is placed in a work-holding anvil in the headstock, in contact with a loading tool in the tailstock. Pressure is applied to the work through a worm and gear. The applied load is measured by hydraulic cell and gage as the work-holding member is forced against a piston in the headstock. Direct readings are made in pounds.

**For further information circle No. 18 on literature request card, page 48-B.**

### *Laboratory Vacuum Furnace*

A new laboratory vacuum furnace capable of attaining temperatures in excess of 3600° F. has been announced by the Vacuum Equipment Div. of the New York Air Brake Co. It has a capacity of 10 lb. of steel or volume equivalent if the crucible is to be tilt-poured, and 25 lb. if bottom-plug pouring is employed. The furnace uses either resistance or induction heating. It can perform either vacuum or inert gas melting and heat treating of metals. Neither the ceramic crucible nor the pouring spout are cemented in place, so if either cracks or breaks, it can easily be replaced. The pumping system can produce pressures of 1 x

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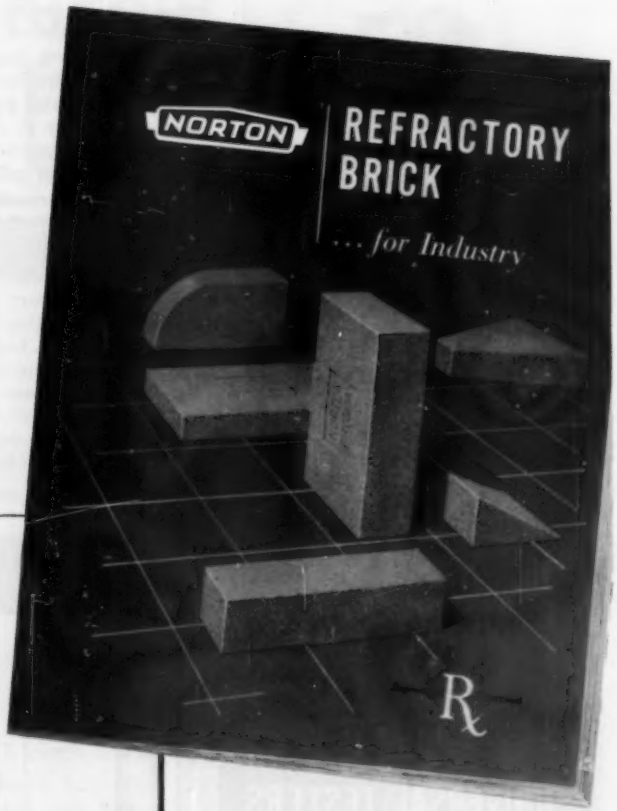


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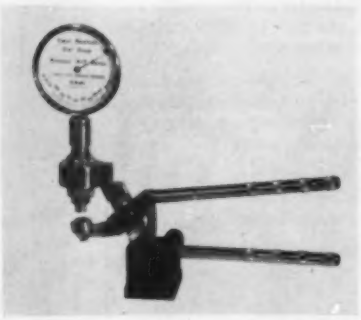
$10^{-4}$ mm. Hg in 18 min. and an ultimate pressure of $3 \times 10^{-5}$ mm. Hg.

**For further information circle No. 19 on literature request card, page 48-B.**

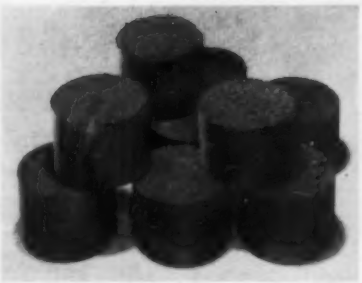
### *Hardness Tester*

The Company for Technical Progress has announced a new method of precision testing of thin sheet metal for cans during the manufacturing process or on stock. The portable



Oppel hardness tester is operated by a plier arrangement. The tester supplies readings directly in Rockwell 30-T units. The measuring range of the instrument extends from 45 to 80 R-30-T.

**For further information circle No. 20 on literature request card, page 48-B.**



### *Sponge Iron*

Hoeganaes Sponge Iron Corp. has announced 3-lb. briquettes of sponge iron for melting stock for the steel industry. The following elements are nonexistent or present in trace amounts only: nickel, molybdenum, cobalt, zinc, hydrogen, nitrogen, chromium, copper and tin. Ancor sponge iron has a 96% reduction.

**For further information circle No. 21 on literature request card, page 48-B.**

### *Tool Steel*

Three improved die steels have been announced by the Latrobe Steel Co. One of the three is a newly patented water hardening steel, Hedervan, 0.90% carbon steel. Others are a 5% chromium die steel, Viscount 20, recommended for extrusion dies, die casting dies and other hot work applications where improved machinability is of primary importance, and a prehardened 5% chromium steel, Viscount 44.

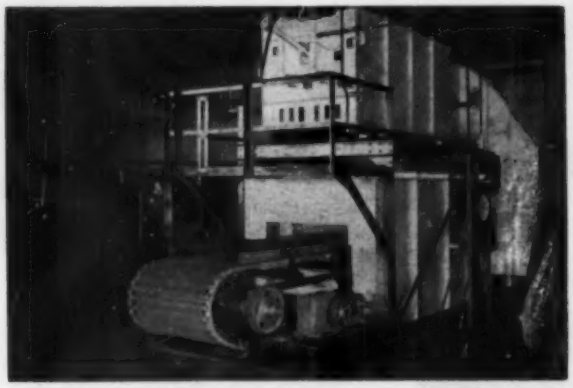
**For further information circle No. 22 on literature request card, page 48-B.**

### *Spray Gun*

The Nordson Co. has announced a new automatic airless spray gun. By applying hydraulic pressures to heated finishing and coating materials and eliminating atomizing air, overspray is reduced. The new spray gun is de-

signed to operate at speeds up to 3000 cycles per min. It employs frictionless seals instead of packings. A carbide needle floats in the material being sprayed and is controlled by a finger which operates within a teflon boot. Both paint hoses and trigger-air hose are located at the rear of the gun. The gun weighs 2 lb.

**For further information circle No. 23 on literature request card, page 48-B.**

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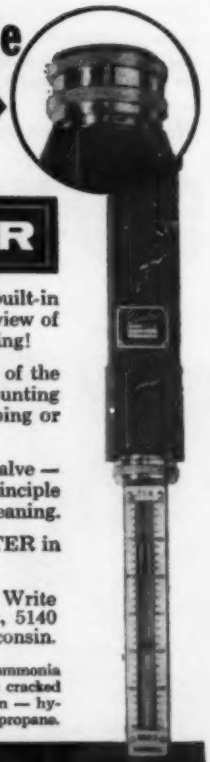
*Waukee*

**FLO·METER**



With the Waukee FLO-METER'S built-in Valve, you adjust the gas flow in full view of the scale. You can see what you're doing!

The Control Valve is an integral part of the FLO-METER, designed for panel mounting and simple piping. No extra valve piping or installation. Saves time and money.

It's a Waukee-designed and built valve — sturdy, simple, smooth. Needle-valve principle for accuracy, sensitivity, and easy cleaning.

And you can still clean the FLO-METER in 5 minutes *or less!*

Complete information in Bulletin 203. Write for it. Waukee Engineering Company, 5140 North 35th Street, Milwaukee 9, Wisconsin.

For measuring: air — ammonia — dissociated ammonia — argon — butane — city gas — endothermic cracked — exothermic cracked — forming gas — helium — hydrogen — natural gas — nitrogen — oxygen — propane.

*Waukee* FLO METERS • AIR-GAS MIXORS
INDUSTRIAL WASHING MACHINES

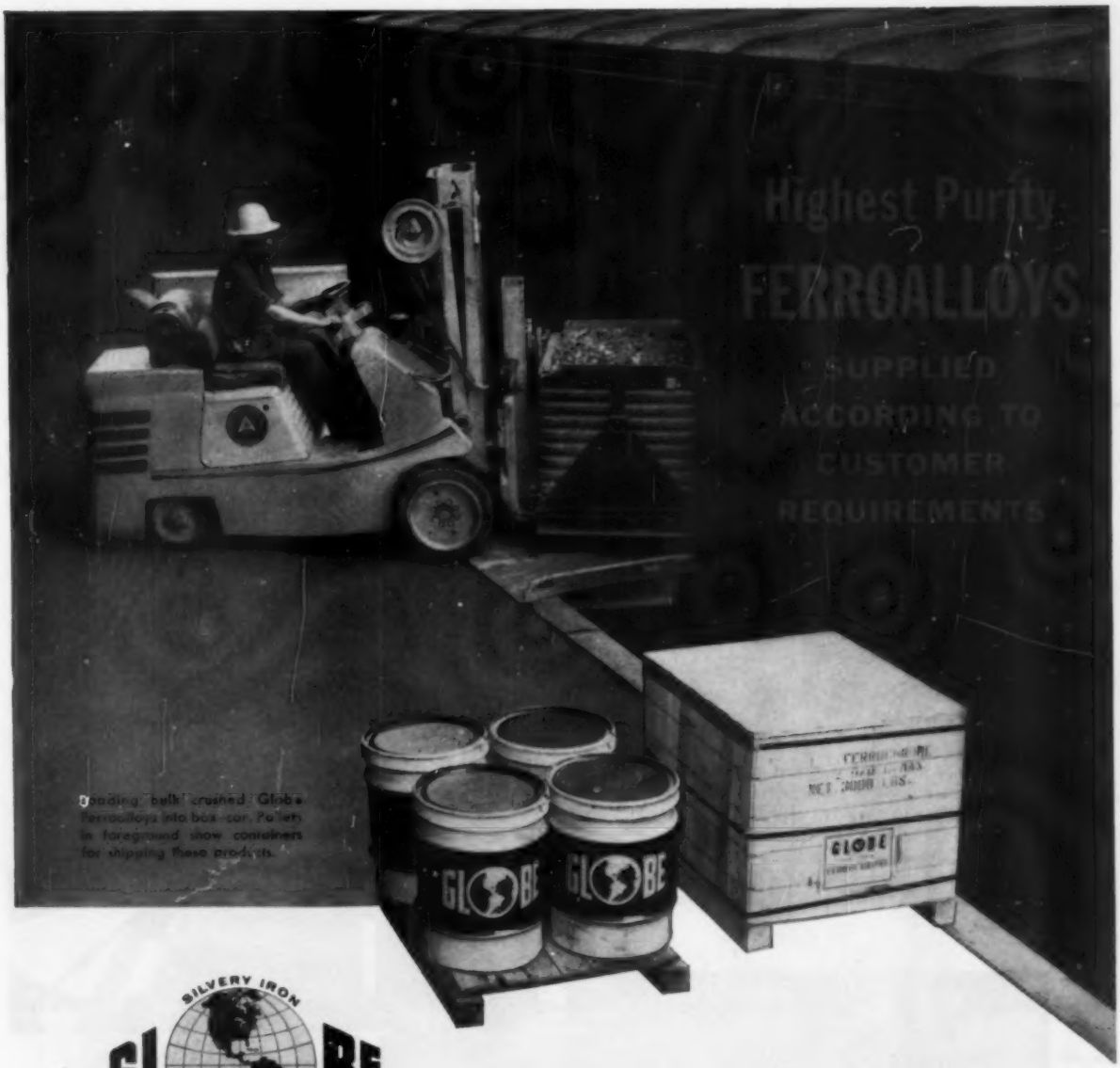
**New Improved — Better Than Ever**
**THE STROMAN ELECTRIC RESISTANCE FURNACE**

For delivering quality melted metal faster to die casting and permanent mold machines this new Stroman Electric cannot be beat. It is designed for holding aluminum and does it so perfectly right up to the highest of casting temperatures. It has an absolutely quiet bath with no turbulence and is noiseless in operation. Dross formation is extremely low and metal may be held overnight or over the week-end with no appreciable damage or loss. Service is so simple as the roof of the furnace is removable for cleaning and maintenance.

This Stroman Electric Furnace comes as a complete package of Control Panel, Transformer and Furnace, delivered, ready to operate on 220 V or 440 V — 3 phase 60 cycle AC, with capacities of 500-800-1500 & 2000 pounds.

This Stroman Furnace has many, many more exclusive features that make it the most efficient and economical Electric Resistance Furnace you can buy. Why not have a chat with one of our metallurgists and let him show you how one of these furnaces can benefit your plant. Drop a line to-day . . . Do it now!

**STROMAN** FURNACE & ENGINEERING COMPANY
9900 FRANKLIN AVENUE, FRANKLIN PARK, ILLINOIS




Loading bulk crushed Globe Ferroalloys into box car. Pallets in foreground show containers for shipping these products.

SILVERY IRON
GLOBE
FERRO ALLOYS

**FERROSILICON**
**HIGH-CARBON FERROCHROME**
**LOW-CARBON FERROCHROME**
**LOW-CARBON FERROCHROME SILICON**
**SILICOMANGANESE**
**OTHER SPECIALTY ALLOYS**

Top grade raw materials and rigid quality control, in modern plants, assure production of highest purity Globe Ferroalloys.

Keen interest in customers' needs and careful attention to details result in supplying these ferroalloys in conformity with requirements.

We welcome your inquiry.

PM

**PICKANDS MATHER & CO. • CLEVELAND 14, OHIO**
CHICAGO • CINCINNATI • DETROIT • DULUTH • ERIE • GREENSBORO • ST. LOUIS • WASHINGTON
***Serving Industry Since 1883***
**IRON ORE • PIG IRON • COAL • COKE • FERROALLOYS**

# ELECTRONIC and ULTRASONIC quality control of MUELLER rod, tube, fabricated parts and

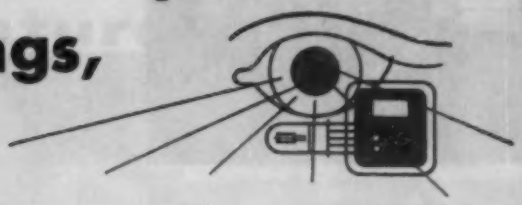
Every practical electro-mechanical testing device available to industry today is used by the Mueller Brass Co. to maintain Positive Quality Control during each manufacturing operation. From the first stages of alloying, spectroscopic analysis is used to maintain exact alloy composition so that they are precisely as specified. Ultrasonic test equipment is utilized in the non-destructive testing of extruded brass and bronze rod, copper tube, forgings and fabricated parts. In machining and finishing operations, statistical quality control is employed to eliminate the effect of possible human error. These quality controls are all designed for one purpose . . . to give you complete "product protection."

•

Copper base alloy rod is examined by a trained operator with the aid of an ultrasonic reflectoscope. Through electronic circuitry, ultrasonic echoes are translated on a cathode ray tube. Any internal flaws are readily apparent. Both rod and tube are tested by this method, which is just one of many Positive Quality Control checks used by the Mueller Brass Co.

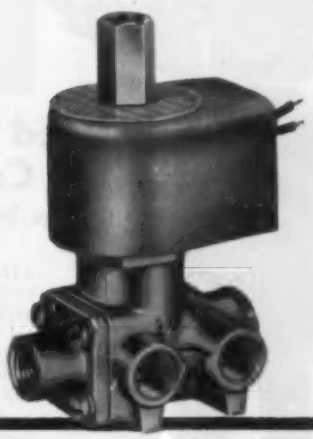
Through ultrasonics, the immerscope (Left) locates internal defects, and has exceptional versatility for examining intricately shaped parts, such as the forging being checked in this photo. When testing, a transducer, located at the bottom end of the search tube, is electronically actuated to produce from 2.2 to 25 million cycles per second. Ultrasonic echoes are reflected back to the transducer from the material, indicating any defects that may be present. Limits may be pre-established and the sound findings are visually recorded on the cathode tube. This is another instance of Positive Quality Control in action.

# TESTING helps insure positive BRASS CO. forgings, assemblies...



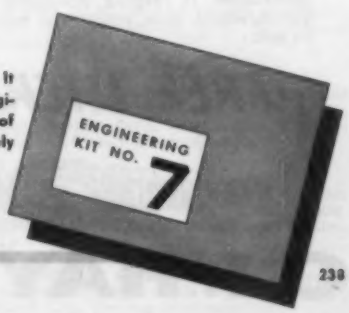
The direct reading spectrometer (Left) makes it possible to accurately analyze an alloy for chemical composition within 90 seconds while the metal is in the molten stage. A sample specimen is poured, cooled and sent to the laboratory, where it is placed in the spectrometer. Through the diffraction gratings in the machine, the "spectrum" analysis of the alloy records its exact chemical composition. With this equipment, alloy specifications are matched exactly, thus insuring a better finished product through Positive Quality Control.

THIS MIDGET 4-WAY SOLENOID VALVE (Right) is one of a complete line designed and manufactured by the Automatic Switch Co. (ASCO) of Florham Park, New Jersey. Valves of this type are used for controlling small double acting cylinders which operate valves, dampers and many types of automatically controlled equipment. One of the most important components in these valves is the non-porous brass body forged by the Mueller Brass Co. who also perform all the major machining operations so that the body is ready for use upon delivery. The forged brass body insures freedom from porosity and reduces possibility of corrosion. The Mueller Brass Co. Positive Quality Control program insures ASCO complete "product protection". . . and eliminates chance of "in-service" failures.



THIS LARGE 18" FORGED GEAR, along with two others of the same type, is used in a steam turbine installed in a power generation facility of the Wisconsin Electric Power Company, at Port Washington, Wisconsin. The gear was forged in open dies by the Mueller Brass Co. from tough, long-wearing 603 alloy. The gear operates at 25-30 RPM and is turned by the turbine, which has a capacity of 80,000 kilowatts. Strength and dependability are of utmost importance in applications like this, and in such cases Positive Quality Control insures peak performance.

Write for your engineering kit no. 7. It contains complete laboratory and engineering data plus typical examples of Mueller Brass Co. products used in widely diversified applications.

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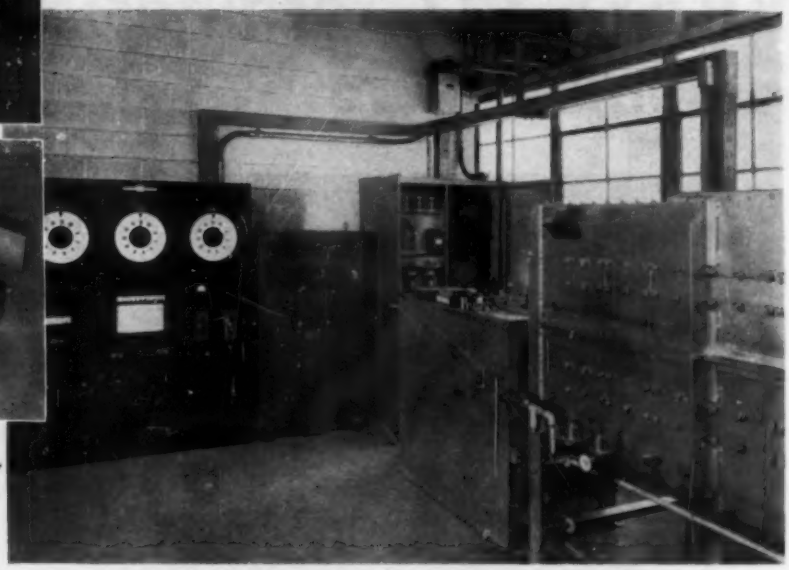
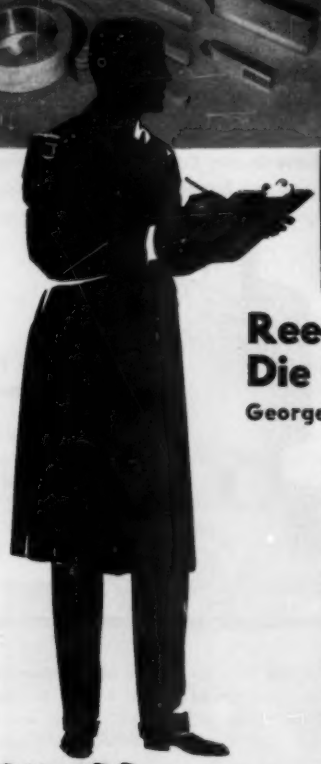
**MUELLER BRASS CO.** PORT HURON 28, MICHIGAN

# AUTOMATION . . . first known Conveyorized Heat Treating of High Carbon, High Chrome Steel

## rolled thread dies





## Reed Rolled Thread Die Company Gets...

**George W. Lyman, Chief Engineer**

- "Uniformity of Austenitizing Cycle,
- Absolute Control of Surface Chemistry,
- Minimized Handling Damage"

The Reed Rolled Thread Die Company of Holden, Mass., recently installed a Hayes LAC furnace equipped with Hayes Ampro process atmospheric control to heat treat their flat, cylindrical and planetary thread rolling dies made of high carbon-high chrome steel.

Uniformity of the austenitizing cycle, absolute control of the thread surface chemistry, and reduced possibility of damage to the thread crests of the dies are the outstanding features which led to the selection of Hayes equipment and process.

Temperature in the three zone heating and the water-jacketed cooling sections of the furnace is closely controlled. Scaling of the dies has been eliminated, and the carbon content of the die surfaces is controlled by using dew point measurements to regulate the proportions of dissociated ammonia and propane in the furnace atmosphere according to the Hayes formula. By heating and cooling in the same piece of equipment, objectionable handling damage is minimized.

***YOU TOO...*** can find the ideal solution to your heat treating problems at C. I. Hayes. The unique Hayes Laboratory contains an extensive line of production heat treating equipment on which to develop customized plant procedures. If existing equipment does not meet YOUR specifications, new equipment will be designed and built to suit.

***YOU TOO...*** can be assured of GUARANTEED RESULTS designed to improve your product, increase output, and reduce unit costs. Let us show you what over fifty years experience in developing the well known line of CERTAIN CURTAIN electric furnaces and allied equipment can do for you. Write today!

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Please send complete data. I am mostly concerned with the following heat treating procedures.

- ☐ High Speed Hardening
- ☐ Tool Steel Hardening
- ☐ Carbo-Nitriding
- ☐ Tempering
- ☐ Vacuum Heat Treating
- ☐ Bright Heat Treating
- ☐ Stainless Steel Heat Treating
- ☐ Sintering
- ☐ Copper Brazing and Soldering
- ☐ Lead Pot Hardening and Tempering
- ☐ Atmosphere Equipment
- ☐ Other

Name..... Title.....

Company.....

Street.....

City..... State.....

# APPLICATION and EQUIPMENT new literature

### 31. Abrasive Cleaning
Folder on Malleabrasive for airless blast cleaning equipment gives advantages, grades, equipment it can be used with and parts that can be cleaned. *Globe Steel Abrasive*

### 32. Air Washers
Bulletin No. 256 on acid-proof air washers for ventilation systems. Construction and accessories. *Automotive Rubber*

### 33. Alloy Applications
New booklet on use of cobalt, nickel and iron-base alloys for machinery parts. Heat treatment, machining, grinding and forging of machinery parts. *Haynes Stellite*

### 34. Alloy Steel
40-page book on applications of heat treated, special alloy steel. *Jones & Laughlin*

### 35. Alloy Steel
32-page book on abrasion resisting steel. Properties, fabricating characteristics, uses. *U. S. Steel*

### 36. Aluminum
16-page bulletin lists sizes, weights, lengths of aluminum in rod, bar, plate, sheet. Guide to selection, finishes, mechanical properties. *Ryerson*

### 37. Aluminum Die Castings
Bulletin on design and manufacture of aluminum die castings. *Hoover Co.*

### 38. Aluminum Extrusions
Folder lists alloys used, finishes, trade phraseology. *General Extrusions*

### 39. Aluminum-Iron Alloys
New Technical Data Bulletin IND-18 on aluminum-iron alloys for applications requiring high quality, soft magnetic materials. *General Plate Div., Metals & Controls Corp.*

### 40. Aluminum Melting
Folder on electric furnaces for the aluminum alloy foundry. *Ajax Engineering*

### 41. Ammonia
New technical bulletin on commercial and refrigeration grades of anhydrous ammonia. Physical-chemical properties, specifications. *Sun Oil Co.*

### 42. Ammonia Dissociator
12-page bulletin B-53 on ammonia dissociation equipment. Sizes and capacities, testing unit, cost chart. *Drever Co.*

### 43. Analysis of Nickel Alloys
52-page Technical Bulletin T-36, "Methods for Chemical Analysis of Nickel and High-Nickel Alloys". *International Nickel*

### 44. Atmosphere Furnace
12-page bulletin 1054 on electric furnaces with atmosphere control for hardening high speed steel. *Sentry*

### 45. Atmosphere Furnaces
New brochure describes various hydrogen atmosphere furnaces for heat treating and brazing stainless steels. Ammonia dissociators for use with this equipment. *American Gas Furnace*

### 46. Atmosphere Furnaces
4-page bulletin on furnaces for hardening high carbon and high speed tool steels. Diagrams, specifications and performance data. *Lindberg Engineering*

### 47. Atmospheres
12-page booklet on design and use of special atmospheres for industrial furnaces. *Continental Industrial Engrs.*

### 48. Atmospheres
8-page Bulletin SC-155 discusses following controlled atmospheres: RX, DX, NX, HNX, AX, HX. Compositions, applications, effects on steel, drawings of generators. *Surface Combustion*

### 49. Blast Cleaning
New 24-page Bulletin 100C on blast cleaning hose machines. Selection and uses. *Pangborn Corp.*

### 50. Bolts
16-page booklet on high-strength bolting for structural joints includes ASTM specifications covering this bolting material. *Bethlehem Steel*

### 51. Brass
New Publication B-39 on superfine-grain drawing brass. Properties. Finishing characteristics. *American Brass*

### 52. Brazing
New 24-page Bulletin 20 on low-temperature silver alloy brazing. *Handy & Harman*

### 53. Brazing Alloys
New reference chart on brazing alloys that meet all Government, A.S.T.M. and A.W.S. specifications. *American Brazing Alloys Co.*

### 54. Brazing Carbide
Bulletin 542 on brazing hard carbide with Silvaloy plymetal. Joint requirements, brazing procedure, thermal stress in brazing carbide tips. *American Platinum Works*

### 55. Bronze
New 9-page metallurgical report on high strength nickel silicon bronze alloy. Properties, fabrication and specification data. Eight tables. *Chase Brass*

### 56. Carbon Control
16-page bulletin on equipment for carbon and sulphur determination, including combustion furnaces and other accessories. *Harry W. Dietert*

### 57. Carbon Control
Bulletin C-22 and reprint on Carbontronik for automatic control of carbon potential of atmospheres. *Ipsen*

### 58. Castings
Bulletin 3150-G on castings for heat, corrosion, abrasion resistance. *Duraloy*

### 59. Castings
New 24-page folder on aluminum permanent mold and sand castings. Application, specifications, physical properties and characteristics. *Permold Co.*

### 60. Chromate Finishing
File on chromate conversion coatings for prevention of corrosion and paint-base treatment of nonferrous metals. *Allied Research Products*

### 61. Chromium Plating
4-page bulletin on new "crack-free" chromium plating process. *Metal & Thermit*

### 62. Cleaners
Folder on immersion, electrolytic, spray cleaners, phosphate coaters, strippers, drawing compounds, additive agents. *Northwest Chemical*

### 63. Coated Metals
New bulletin on roll coating shows how it is done and includes samples. *Roll Coater, Inc.*

### 64. Cold Rolled Shapes
New 48-page Handbook MS-158 on roller die, cold forming metal shapes. Material selection, specifications. *Van Huffel Tube Corp.*

### 65. Compressors
12-page Bulletin 126-A on application of turbo compressors to oil and gas-fired equipment used in heat treating, agitation, cooling, drying. Performance curves, capacities. *Spencer Turbine*

### 66. Controlled Atmospheres
New Bulletin No. 2051 on Dewpointer for reading of atmosphere in field and laboratory. Readily portable, operating on a.c. or enclosed battery. *Illinois Testing Labs.*

### 67. Conveyor Belts
Report on service life of woven wire conveyor belts operating at temperatures of 2050° F. *Cambridge Wire Cloth Co.*

### 68. Conveyors
New 8-page Catalog MF-100 on materials handling conveyors and systems. Sections can be assembled to form any type of hinged steel conveyor. *May-Fran*

### 69. Copper Alloys
16-page publication E-5 on physical properties and applications of high-strength, corrosion-resistant copper alloys. *American Brass Co.*

### 70. Creep Testing
Bulletin 4208 on five types of creep testing machines for standard sized metal specimens. *Baldwin-Lima-Hamilton*

### 71. Cutting Tools
36-page booklet analyzes and compares carbon, high speed, cast alloy and carbide tool materials. *Allegheny Ludlum*

### 72. Cutting Tools
12-page catalog D-56 on aluminum oxide cutting metals, tool tips, throw-away inserts, cylinders and other machine turning and cutting tools. *Metal Carbides*

### 73. Degreasers
Folder on vapor and solvent degreasers describes equipment and advantages. *Randall Mfg.*

### 74. Degreasing
New Data Sheet No. 787-A on degreasing with trichlorethylene. Description, uses, specifications, precautionary information. *Hooker Electrochemical*

### 75. Die Steel
Data sheet on Ottawa 60 high carbon, high vanadium die steel. Physical characteristics and tests. *Allegheny Ludlum*

### 76. Ductility Testing
Bulletin on simple method of determining ductility of materials before drawing. *Steel City Testing Machines*

### 77. Electric Furnaces
16-page Bulletin No. 559 on melting,

ACHESON

dispersions digest

Reporting uses for

dag® BRAND DISPERSIONS

COLLOIDAL GRAPHITE, MOLY-SULFIDE, VERMICULITE, AND OTHER SOLIDS

## WHY 'DAG' DISPERSIONS MEAN *PERFORMANCE* IN ALUMINUM EXTRUDING

**The excellent lubricating properties of Acheson Colloidal Graphite, under conditions of extreme heat and pressure have been confirmed by leading extruders of aluminum, steel, copper, brass, lead and other metals. Water-base dispersions of colloidal graphite used in the following application histories have provided savings in material handling, reduced maintenance time and expense, prevented seizure, extended die life, and produced extrusions of more uniformly high quality. Any one of these benefits should make profitable reading for you.**

For faster, more uniform application with less material consumption, Aluminum Extrusions, Inc. finds 'Aquadag' their best die lubricant.

***A little 'Aquadag' goes a long way*** for Aluminum Extrusions, Inc., Charlotte, Michigan. This company, one of the leading independent extruders in the country, has found that by applying 'Aquadag' on die surfaces they have effected a 30% savings in their material handling. Formerly, they had used an oil-graphite mixture which required a dilution ratio of 16 lbs. of graphite to a 55 gallon drum of oil. It was too slowly applied by swab and too coarse to apply by spray with any degree of efficiency.

With 'Aquadag', Aluminum Extrusions has a lubricant that is finer in particle size, permits wider coverage, and provides greater "sprayability". These minute particles pass freely through the spray nozzle, eliminating the costly downtime formerly involved in cleaning clogged equipment. The tough, dry film 'Aquadag' forms upon the evaporation of its water carrier, doesn't smoke or react when applied to hot dies and metals. This improves working conditions as well as extends die life. Important also to both die surfaces as well as the finished extrusion, is the fact that this durable, low-friction film allows easier, more uniform metal flow.

Considered in relation to the over 12 million pounds of aluminum extruded yearly at this plant . . . 85% of it in fabricated form . . . *'Aquadag' has brought important production efficiencies and material economy* to Aluminum Extrusions, Inc. In many, similar instances where product quality and basic economy are demanded, Acheson colloidal dispersions have gained ready acceptance.

Exclusive Acheson processing techniques guarantee a consistently uniform top-quality product. If your problem is more effective lubrication under normally adverse conditions of extreme temperature, pressures, or abrasion, call in your Acheson Service Engineer.

***Dies last three times longer with 'Aquadag',*** according to another prominent midwest extruder. Metal pickup on the extruding dies has been completely eliminated by the use of this Acheson dispersion, extending the effective use of the dies from 1000 to 3000 strokes. The evaporation of its water-base leaves a dry, adherent "graphoid" film on all lubricated surfaces, inhibiting the build-up of abrasive precipitates. At the same time, the unbroken, microscopically-thin film that 'Aquadag' provides, facilitates metal flow and reduces scoring to a negligible minimum. Application of the lubricant is by spraying a dilution of 1 part 'Aquadag' to 20 parts water, on the die surface before each "push" of the extrusion press.

A 'dag' graphite coating is also applied to the follow blocks on this company's 1400 ton horizontal extrusion presses. For purposes of even greater economy, 'Prodag' — semi-colloidal graphite in water — is used in this application. This effective parting agent prevents the flash, back-extruded from the billet skin, from locking the butt to the follow block. An Acheson dispersion is very possibly the answer to your lubricating troubles. For additional information, write for your free copy of Bulletin 426. Address Dept. MP-48.

Extended die life and extrusions with more perfect surface finish, are attributed to the use of 'Aquadag'.

**ACHESON** *Colloids Company*

PORT HURON, MICHIGAN

*A division of Acheson Industries, Inc.*

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investment casting and other furnaces. Capacities and special features. *Detroit Electric Furnace*

**78. Electric Furnaces**
Bulletin on electric heat treating furnaces gives summary of progress in furnace developments. *Holcroft*

**79. Electric Furnaces**
8-page Bulletin 570 on heat treating, melting, metallurgical tube, research and sintering furnaces. Custom designs for special requirements. *Pereny*

**80. Electrochemicals**
New 16-page booklet gives physical properties of 23 electrochemicals including silicon carbide, zirconium oxide and borides. *Norton Co.*

**81. Electrodes**
Bulletin 810 on removable submerged electrodes. Advantages. *Ajax Electric*

**82. Electron Microscope**
20-page brochure describes ten case histories in which the electron microscope has been at work solving problems of development and control. *RCA*

**83. Finishing**
New 44-page Catalog 1169-B on 15 models of finishing machines. Automatic size control, floor plans for all models, applications. *Gisholt Machine Co.*

**84. Flame Hardening**
New bulletin tells how flame hardening improves rolls. Chart shows ranges and depth of hardness. *Detroit Flame Hardening Co.*

**85. Flow Measurement**
8-page Bulletin SC-1022 on instrument for measurement of flow rate of air and gases. *Selas Corp.*

**86. Flow Meters**
Bulletin 203 on flow meter for gas used in heat treating. *Waukee Eng'g.*

**87. Forgings**
Series of articles on modern forging methods. *Hill Acme*

**88. Forgings**
Bulletin on forge steelmaking, open die forging, machining, heat treating and finishing. *National Forge*

**89. Forgings**
12-page booklet on how forged weldless rings and flanges are made. Case histories. *Standard Steel Works Div., B-L-H*

**90. Formed Shapes**
26-page catalog No. 1555 contains drawings and dimensions of more than 100 shapes. *Roll Formed Products Co.*

**91. Freezer**
Data on chest for use down to −95° F. for production and testing. *Revco*

**92. Furnace**
New Bulletin 5709 on vacuum heat treating furnace. Temperature range 600° F. to 2150° F. Design features, performance data and applications. *C. I. Hayes*

**93. Furnace**
4-page bulletin KM-570 on Karbo-Matic automatic furnace for hardening, carbonitriding or carburizing. Operation. Heating elements. *Pacific Scientific*

**94. Furnace Belts**
44-page catalog describes metal belts for quenching, tempering, carburizing and other applications. *Ashworth Bros.*

**95. Furnace Fixtures**
16-page catalog on baskets, trays, fixtures and carburizing boxes for heat treating. 66 designs. *Stanwood*

**96. Furnaces**
12-page reprint on design, construction and application of chain belt conveyor furnaces. *Electric Furnace Co.*

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**Ductility Testing**
quick & easy

The turning of a single hydraulic control knob clamps the specimen, tests it, then releases it. The test is made in plain view, and the maximum pressure indicators show the result until reset. This highly sensitive sheet metal tester will take up to 3/16" thick specimens and exert up to 30,000 pounds pressure, at any desired rate of speed. Hydraulic mechanism is all neatly enclosed. Write for catalog sheet and prices.

DETROIT TESTING MACHINE COMPANY

*9384 Grinnell Ave., Detroit 13, Mich.*

'PSC' RADIANT TUBES in
Any Design or Dimension
Send for PSC Heat-Treat Catalog 54
PSC fabricated tubes furnish four substantial advantages: (1) Light-wall construction saves furnace time and fuel. (2) Return bends are of same wall thickness as tubes, promoting uniform flow of gas. (3) Smooth dense walls minimize carbon build-up and burn-out. (4) Up to 100% longer life. In any alloy, size or type, including parabolics. Also sheet-alloy heat-treating retorts and covers, boxes, baskets, fixtures, tubes, etc.
PSC
THE PRESSED STEEL CO. - Wilkes-Barre, Pa.

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**EXHIBIT AT SOUTHWESTERN METAL SHOW — DALLAS, MAY 12-16, 1958**

Staff and Representatives were honored by the cordial reception and recognition given

**the First Exhibit of ENGINEERED Heat and Corrosion Resistant Castings presented in the Southwest area.**

**THANKS**—to present Texas and other Southwest customers for helping display our products now establishing outstanding service records.

**THANKS**—for the interest shown in our unique design contributions; our proprietary casting technology; and our unparalleled R & D experience — all available to our customers in SUPERIOR PRODUCTS that do a BETTER JOB at LOWER ULTIMATE COST.

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**Tel. WH-1-4994**

ENGINEERS AND PRODUCERS OF HEAT AND CORROSION RESISTANT CASTINGS

**97. Furnaces**
Folder describes complete set-up for heat treatment of small tools, including draw furnace, quench tank and high temperature furnace. *Waltz Furnace*

**98. Furnaces**
Catalog on standard and special furnaces and ovens to 3000° F. *L & L Mfg.*

**99. Furnaces**
Bulletin on electric heat treating furnaces describes five series and accessories. *Lucifer Furnaces*

**100. Furnaces**
Lists of surplus furnaces for sale. *Joe Martin Co.*

**101. Furnaces**
4-page reprint on high thermal head furnaces for continuous slab heating installation at Atlas Steels, Inc. Cross section view of radiamatic unit. *R-S Furnace*

**102. Furnaces**
New Bulletin SC-163 on controlled atmosphere batch furnaces. One man operation. *Surface Combustion*

**103. Gas Blenders**
New Bulletin GB 10-57 on machine to control gas mixing. *Gow-Mac Instrument*

**104. Gold Plating**
Folder on salts for bright gold plating. Equipment needed. *Sel-Rex*

**105. Gold Plating**
Folder gives data on plating to obtain a hard bright gold finish. *Technic*

**106. Graphite**
New 12-page booklet on "The ABCs of Colloidal Dispersions". Answers to questions most frequently asked about colloids. *Acheson Colloids Co.*

**107. Graphite**
New bulletin on colloidal graphite dispersions for industry. 17 uses listed. Tables on concentrated and ready-for-use solutions. *Graphite Products Corp.*

**108. Gripping Fixtures**
New bulletin on line of gripping fixtures for use in tension, compression, transverse or shear to test any material. W. C. *Dillon*

**109. Hardness Tester**
20-page book on hardness testing by Rockwell method. *Clark Instrument*

**110. Hardness Tester**
Bulletin A-16 on micro-reflex hardness testers. Loads to 3000 gr. Zeiss optical system. *Gries Industries, Inc.*

**111. Hardness Tester**
Bulletin on Brinell tester with test head for deep and offset testing. *King Tester*

**112. Hardness Tester**
4-page bulletin on portable metal hardness tester for any shape or metal. Ranges, features. *Newage Industries*

**113. Hardness Tester**
Catalog 72-1 on Leitz miniload tester for Vickers and Knoop hardness tests. *Opto-Metric Tools, Inc.*

**114. Hardness Tester**
Data on hardness testing scleroscope with equivalent Brinell and Rockwell C numbers. *Shore Instrument*

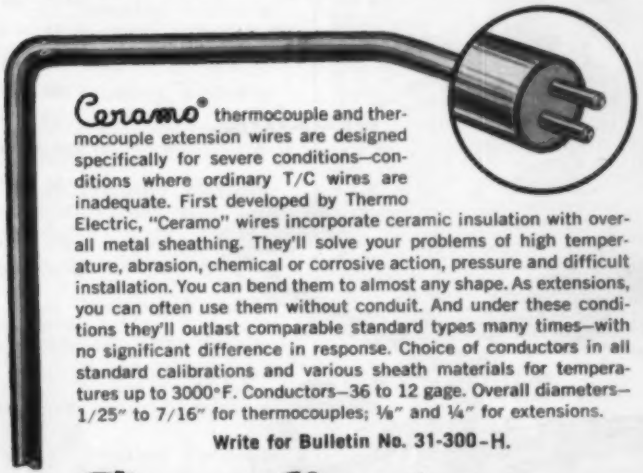
**115. Heat Treat Pots**
Catalog on pressed steel pots for lead, salt, cyanide, oil tempering and metal melting. *Eclipse Industrial Combustion*

**116. Heat Treat Pots**
6-page folder gives stock shapes and sizes. Tips on installation and use. *Electro-Alloys Div.*

**117. Heat Treating**
New 8-page bulletin on heat treating. Data sheets on processes and processing


**Ceramo® Thermocouple Wire Meets Severe Conditions**

**Where Durability, Hi-Temp Resistance Are Needed**

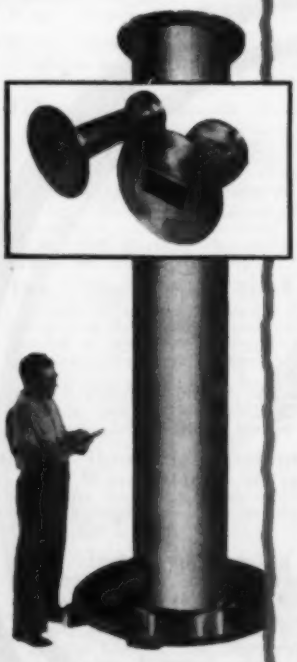


Ceramo® thermocouple and thermocouple extension wires are designed specifically for severe conditions—conditions where ordinary T/C wires are inadequate. First developed by Thermo Electric, "Ceramo" wires incorporate ceramic insulation with overall metal sheathing. They'll solve your problems of high temperature, abrasion, chemical or corrosive action, pressure and difficult installation. You can bend them to almost any shape. As extensions, you can often use them without conduit. And under these conditions they'll outlast comparable standard types many times—with no significant difference in response. Choice of conductors in all standard calibrations and various sheath materials for temperatures up to 3000°F. Conductors—36 to 12 gage. Overall diameters—1/25" to 7/16" for thermocouples; ⅛" and ¼" for extensions.

**Write for Bulletin No. 31-300-H.**

**Thermo Electric Co. Inc.**
SADDLE BROOK, NEW JERSEY
In Canada—THERMO ELECTRIC (Canada) Ltd., Brampton, Ont.





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Tested and certified at the plant for pump down and leak rate measured in microns, ZAK manufactured crucibles 'hold up' under work schedules that 'break down' ordinary crucibles.

The production time saved by longer life will be high; the replacement cost —low!

VARIETY IN SIZE AND SHAPES
Zak manufactures any size or shape from 20 lb. evaluation to production crucibles producing ingots in excess of 6 tons.

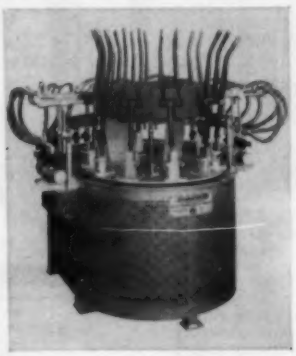
ZAK MACHINE WORKS, INC., are engineering manufacturers of special Vacuum Applications for Melting, Annealing and Processing.

**ZAK MACHINE WORKS INC.**
TROY (GREEN ISLAND) N. Y.

## Columbia produces 250 bicycle forks per hour with automatic GAS brazing

Gas brazing is not new to Westfield, where Columbia bicycle frames have been brazed with Gas-fired Selas processing equipment for many years. During this time, pre-placing of brass filler material and automatic heating have limited dependence on operator skill, reduced material waste, and eliminated costly cleanup operations. With the installation of the new Gas brazing machine in their production operation, these advantages have been extended to include fork manufacture, also.

For information on how Gas equipment can help you in your production operations, call your Gas Company's industrial specialist. He'll be glad to discuss the economies and outstanding results you'll get with Gas and modern Gas equipment. *American Gas Association.*



Two fork styles in all standard bicycle sizes are joined from eight steel components on this new automatic Selas machine by Westfield Manufacturing Co., Westfield, Mass. Controlled combustion and flame geometry bring the parts to brazing temperature of 1750°F in only 86 seconds, using economical Gas equipment.

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equipment. Also covers annealing, brazing and hardening. *Ferrotherm*

**118. Heat Treating Ammonia**
24-page "Guide for Use of Anhydrous Ammonia" describes heat treating and other metallurgical uses. *Nitrogen Div.*

**119. Heat Treating Belts**
New 16-page booklet on selection of steel processing conveyor belts gives complete specifications. *Wickwire Spencer*

**120. Heat Treating Fixtures**
4-page folder on retorts, baskets, trays, carburizing boxes, fans for heat treating. *Aluminum & Architectural Metals Co.*

**121. Heat Treating Fixtures**
24-page catalog on heat and corrosion-resistant equipment for heat treating and chemical processing. 30 classifications of equipment. *Pressed Steel*

**122. Heat Treating Fixtures**
32-page catalog G-10A lists process equipment, heavy welded fabrications, muffles, trays, fixtures for furnaces, heat-treating equipment, pickling equipment. *Rolock*

**123. Heat Treating Fixtures**
12-page bulletin on wire mesh baskets for heat treating and plating. *Wiretex*

**124. Heat Treating Furnaces**
New Bulletin No. HT-53 on heat treating furnaces. Construction, design, fuel used. *Carl-Mayer*

**125. Heat Treating Furnaces**
New 12-page Bulletin 81 on recirculating furnaces for heat treating aluminum alloys, annealing and stress relieving. Conveyorized, pot and batch types. *Despatch Oven*

**126. Heat Treating Furnaces**
Folder on industrial furnaces. Continuous designs. Insulation. *Pacific Industrial*

**127. Heat Treating Furnaces**
Monthly bulletin on used furnaces. *Metal Treating Equipment Exchange*

**128. Heaters**
Bulletin on immersion heaters for electroplating solutions. *Glo-Quartz*

**129. High-Strength Steels**
48-page booklet on applications of seven nickel-copper high-strength low-alloy steels. *International Nickel*

**130. High-Temperature Alloy**
14-page bulletin on Udimet 500 gives composition, heat treatment, machinability, hot working characteristics and properties. *Utica Metals Div.*

**131. High-Tensile Steel**
8-page bulletin on properties and composition of N-A-X high-tensile steel. Examples of resistance to impact, fatigue, abrasion and corrosion. *Great Lakes Steel*

**132. High-Vacuum Pump**
4-page bulletin on small, air-cooled, compound, high-vacuum pumps. *Kinney*

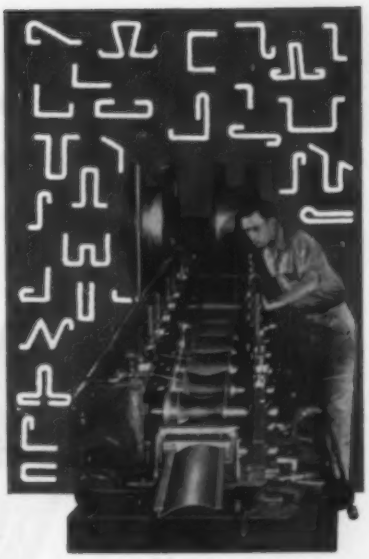
**133. Humidity Instruments**
New 22-page bulletin on indicating, recording and controlling wet and dry bulb instruments and psychrometers. *Bristol Co.*

**134. Induction Brazing**
Folder tells how tips of carbide may be brazed on tool shanks. *Ohio Crankshaft*

**135. Induction Heating**
20-page booklet, "Dr. Northrup's Fireless-Wireless Furnace", gives story of development of high-frequency induction heating. *Ajax Electrothermic Corp.*

**136. Laboratory Equipment**
New bulletin on cutting test specimens describes methods for different types of metals. Price list. *Sieburg Industries*

(Continued on page 48-A)

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# A Brazing Story in Five Parts ...with Handy & Harman EASY-FLO

The Perlman Heat Treating Corp., Westbury, Long Island, brazes aircraft fuel system parts for WEBA, Inc. One of these is a fuel filter screen. It consists of five parts: two stiffeners, a screen and two end fittings, all of 302 stainless steel. All of these parts are joined by EASY-FLO silver brazing, using both induction and hand-torch heating methods.

A novel feature is the induction heating method used to braze the two stiffeners to the screen. It is sort of an "upside-down" method, through an asbestos board and carbon block, on which the screen rests with the EASY-FLO wire preform preplaced. The board and block permit enough passage of heat to melt the alloy to the mesh and stiffeners without excess overflow. Because the alloy won't wet the carbon block, the result is a clean, finished fillet.

The larger, cage-type fitting is HANDY-FLUXED, as is the circular preform of EASY-FLO, then assembled and placed in an induction coil. The smaller end fitting is inserted in the screen, preheated by induction and then torch-brazed, with the alloy being hand-fed. Alloy cost for the entire assembly is ten cents.

The main point here is the adaptability not only of the alloy, but the *brazing method.* Hardly anything stands in the way of brazing that a little ingenuity can't solve, as Perlman Heat Treating has demonstrated. We'll be very glad to bring the full and very beneficial brazing story to your attention. More and more, people with all kinds of metal-joining problems are finding that Handy & Harman silver alloy brazing has most of the answers. Answers that may benefit you.

**FIRST, BULLETIN 20** — This informative booklet will get you off to a good start on the values, techniques and economies of low-temperature silver brazing. A copy awaits your request.

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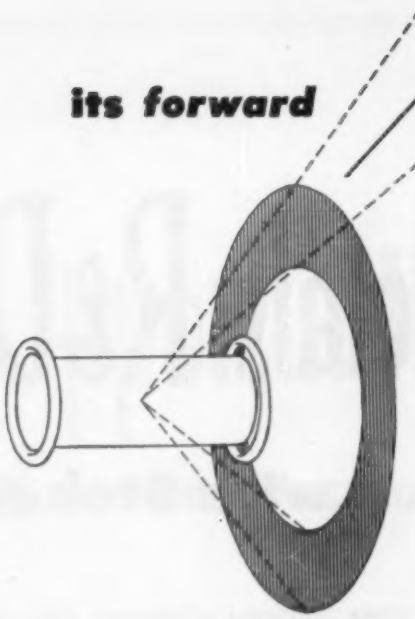
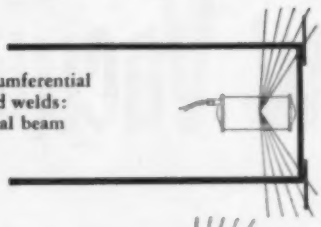
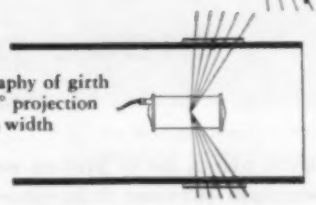


Inside-out one shot circumferential radiography of tank-head welds: the forward-thrown radial beam gets the whole corner.



Circumferential radiography of girth welds: the wide-band 30° projection x-rays the full seam with width to spare on either side.



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*one man can easily carry its 72 lb. tubehead*

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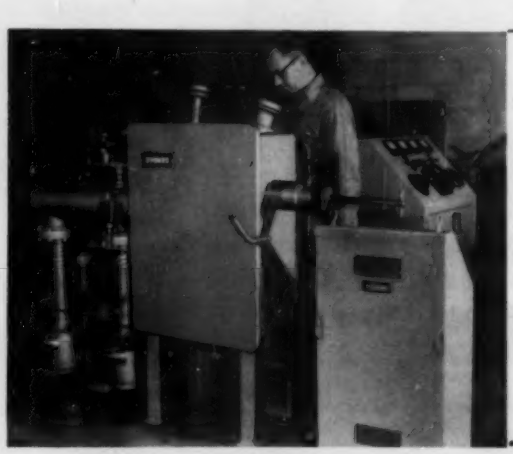
**In your own plant, or in Stokes newly installed vacuum furnace laboratory, early metallurgical investigations can lead to exciting new product and application developments.**

Stokes' extensive design experience and manufacturing facilities combine to make possible these new research and development opportunities in vacuum metallurgy. You have a choice of a complete range of types and sizes of furnaces. The systems are offered complete—placing in Stokes a single-source responsibility for performance and reliability.

Stokes offers additional advantages that can contribute to your successful metallurgical investigations. Stokes can, for example, deliver a complete turnkey installation—erected, tested, and delivered "in operation". Systems benefit from the use of stocked components—facilitating faster delivery. On an economy note, the Stokes system frequently turns out to be the least expensive means of doing the job.

Standard Stokes Vacuum Furnaces, extending from R. & D. into full production size systems, are available for melting, refining, casting, heat-



**THE STOKES VACUUM METALLURGY LABORATORY**

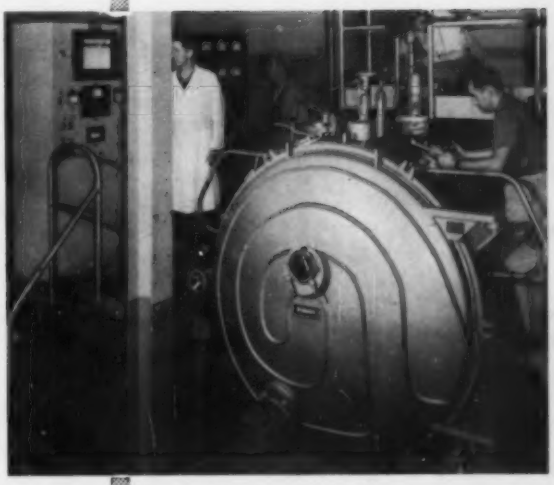
Stokes offers laboratory facilities for vacuum melting and heat-treating. This installation is available as a tool to those interested in learning more about vacuum melting and heat-treating of ferrous or non-ferrous metals, as well as those looking for opportunities to make special vacuum investigations. Set-ups can be made to simulate production cycles, and serve to develop comprehensive recommendations for future production and systems operation procedures.

# Opportunities

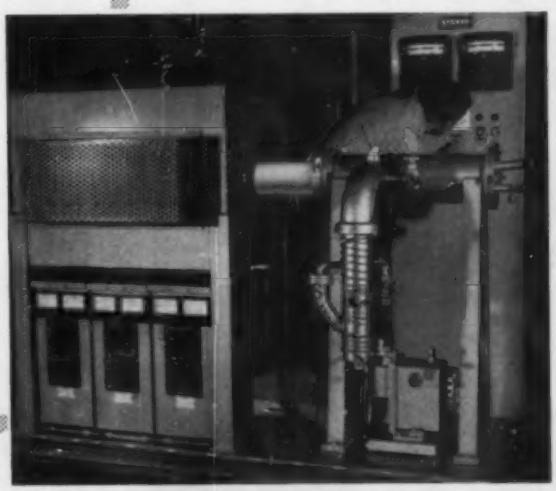
## Vacuum Furnaces

treating, sintering, brazing and stream degassing. In addition, special systems can be custom-designed to meet the exact needs of specific operational requirements. All-the-way service, before and after the sale, completes the picture of how well Stokes is equipped to work with you.

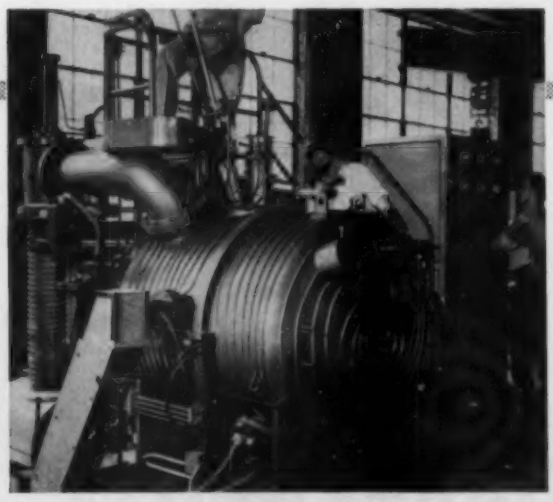
You can take full advantage of Stokes' advanced vacuum technology. The Stokes Engineering Advisory Service will assist you in planning and designing an installation that will best serve your exact requirements. Call Stokes—today.



The General Thomas J. Rodman Laboratory of the Watertown Arsenal, Watertown, Mass., uses this 500 lb. capacity Stokes Vacuum Furnace for research on Titanium, other reactive metals, and radioactive metals. Special locks enable additions to be made or samples taken without breaking the vacuum.



Resistance-heated, two-zone, high temperature Vacuum Heat-Treat Furnace . . . installed for operation over 2500°F. Available in sizes to 9" I.D., for brazing, out-gassing and heat-treating . . . in both research investigations and small parts production.



Stokes Vacuum Furnace, in the Bayonne, N.J. laboratory of International Nickel Co., Inc., is used to study the effects of vacuum melting and casting on nickel base alloys destined for jet engines and other extreme-temperature services. It has a 50-pound crucible.

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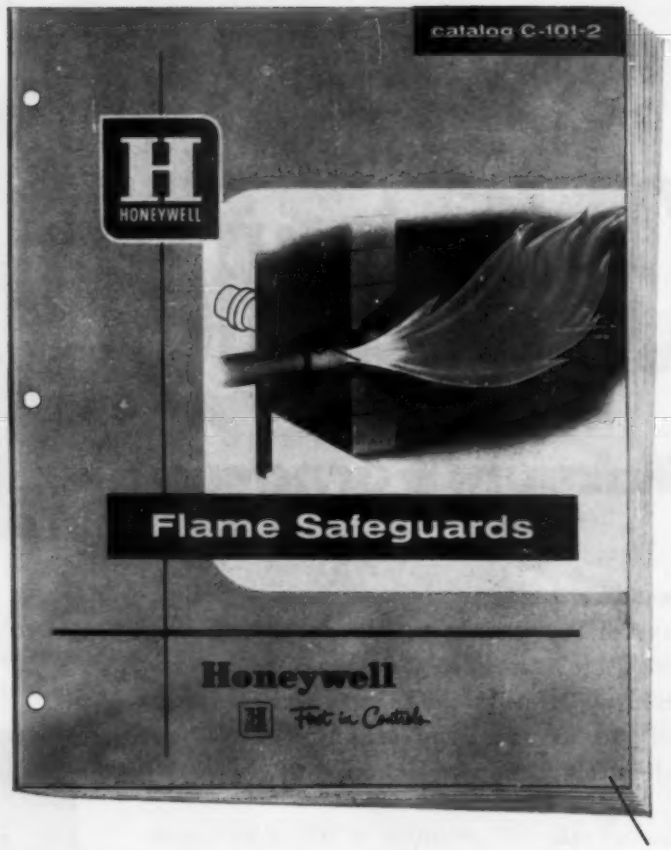


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(Continued from page 43)

**137. Laboratory Furnace**
Data on nonmetallic resistor furnaces for research, testing or small-scale production. *Harrop Electric Furnace*

**138. Laboratory Mill**
4-page reprint on rolling mill for laboratory studies, which may be operated as a 2-high, 3-high or 4-high mill. *Fenn Mfg.*

**139. Laboratory Supplies**
Instruments and apparatus for control, research, development laboratories. *Harshaw Scientific*

**140. Leaded Steels**
16-page booklet on basic characteristics, mechanical properties and workability of leaded steels. Case histories. *Copperweld Steel Co.*

**141. Lubricant**
New 8-page Bulletin 304 on use of molybdenum disulfide lubricant in cold forming, cold heading and other applications. Case histories. *Alpha Molykote*

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8-page booklet, "Biggest Ounce of Protection", tells of lubrication with colloidal graphite products. *Grafo Colloids*

**144. Machining Copper**
12-page bulletin on machining properties, practices, feeds, speeds, tool design. *Ampco*

**145. Magnesium**
New 53-page book on wrought forms of magnesium. Includes 44 tables. *White Metal Rolling & Stamping Corp.*

**146. Manganese Steel**
New booklet on rolled and forged nonmagnetic high-manganese steel. 5 pages of applications. *Manganese Steel Forge Co.*

**147. Marking Machines**
New Bulletins 146-C25 and 146-C26 on complete line of marking machines. *Jas. H. Matthews*

**148. Melting Equipment**
12-page Bulletin IE-11 on gas-fired immersion melting for stereotyping and electrotyping. *C. M. Kemp*

**149. Melting Furnaces**
New Bulletin No. 85 on melting furnaces for brass, bronze, aluminum and other nonferrous metals. *Stroman Furnace & Engineering Co.*

**150. Metal Finishing**
New 30-page brochure on chemical milling. Advantages, engineering applications, operations involved. *Anadite, Inc.*

**151. Metal Powders**
16-page booklet on CDF iron powder. Briquetting characteristics, green strengths, iron sinters, iron-copper mixes, iron-copper bushings and iron-copper-carbon mixes. *Republic Steel*

**152. Metal Treatment**
Booklet on metal treating and finishing products. *John Swift Chemical Co.*

**153. Microhardness Tester**
Bulletin describes the Kentron microhardness tester. *Torsion Balance*

**154. Microscopes**
8-page booklet No. 5 on research microscopes, stages, illuminators and other accessories. *American Optical*

**155. Microscopes**
22-page catalog describes microscopes featuring ball bearings and rollers throughout the focusing system and a low-position fine adjustment. *Bausch & Lomb*

**156. Microscopes**
Catalog on metallograph and several models of microscopes. *United Scientific*

**157. Molybdenum**
24-page booklet gives physical and chemical property data on molybdenum powders, wire, alloys. *Sylvania Electric*

**158. Monel**
Booklet on engineering properties of cast Monel. *International Nickel Co.*

**159. Nondestructive Inspection**
8-page bulletin on use of ultrasonic Reflectoscope describes principles of ultrasonic inspection and its uses. *Sperry Products*

**160. Nondestructive Testing**
8-page bulletin on equipment for nondestructive testing of bars, rods, tubing. *Magnetic Analysis*

**161. Nonferrous Forgings**
34-page booklet on brass, bronze and aluminum forgings. How they are made, composition of alloys, tolerances. *Mueller Brass*

**162. Nonferrous Wire**
Folder gives wire gage and footage chart and data on beryllium copper, phosphor bronze, nickel, silver, brass and aluminum wire. *Little Falls Alloys*

**163. Oil Quenching**
8-page brochure tells in detail how carbon steel often can replace alloy steel when additive is used in the quenching oil. *Aldridge Industrial Oils*

**164. Oil Quenching**
Catalog FB-1052-A on self-contained oil cooling equipment. Selection tables for volume of oil required and oil recirculation rates. *Bell & Gossett*

**165. Ovens**
16-page Bulletin 157 on ovens for baking, drying, curing and heat treating. Batch and conveyor types. Air recirculating and heating systems. *Young Bros.*

**166. Oxygen**
New 16-page brochure on equipment for production of oxygen and nitrogen in liquid or gaseous form. Also pumps, storage and converter tanks. *Superior Air Products Co.*

**167. Permanent Magnets**
New 12-page Catalog No. PR-19 on permanent magnets, magnetizers, and demagnetizers. Over 100 magnets available. *Indiana Steel Products*

**168. Pickling Baskets**
Data on baskets for degreasing, pickling, anodizing and plating. *Jelliff*

**169. Plating**
36-page book gives 28 simple methods of analyzing plating solutions. Electrochemical data. *Hanson-Van Winkle-Munning*

**170. Plating Thickness**
Metal Digest V.3, No. 2, on sample preparation and optical measurement of plating thicknesses. *Buehler, Ltd.*

**171. Powder Press**
New bulletin on 100 ton fully mechanical multi-action powder metal press for conventional punches and dies and withdrawal die sets. *Dorst Div., Arnhold Ceramics, Inc.*

**172. Precision Casting**
8-page bulletin on investment castings of various ferrous and nonferrous alloys. *Engineered Precision Casting*

**173. Presses**
Data on mechanical and hydraulic powdered metal presses 8 to 500-ton capacities. *Haller, Inc.*

**174. Protective Coatings**
New 8-page brochure on chemicals and processes for metal protection. Specification chemicals for the Government. *Amchem Products, Inc.*

**175. Protective Coatings**
Folder 301 on industrial protective coatings of rubber, neoprene and other materials. *Arco Steel Fabricators*

**176. Radiography**
16-page booklet on materials and accessories for industrial radiography. Guide

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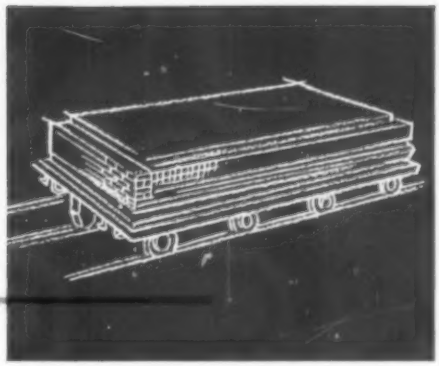

Car-type furnaces solve the problem of heat treating large, awkward-to-handle stock—or large quantities of parts which together form a bulky, heavy load.

Furnaces of this type can be either batch or continuous. In the first case, the load is rolled into the furnace and left there until the heat treat cycle is completed. When several cars are placed in line—the last one added pushing the row of cars through the furnace zones—the operation is continuous.

This is just one major classification of stock handling. Actually, there are several others—each to be considered when selecting a furnace to do a job. This is the type of flexibility you find when you turn your heat treat problems over to Holcroft. Only here do you get the personalized attention—the custom engineering—that slashes your costs and makes possible new standards in quality control.

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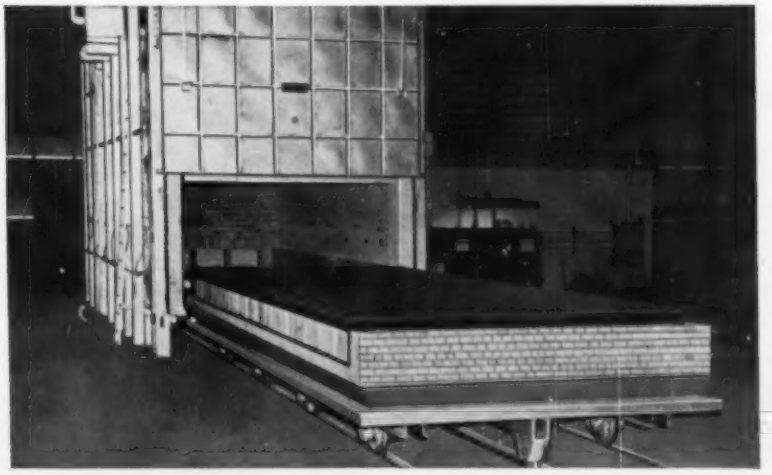
CANADA: Walker Metal Products, Ltd., Windsor, Ontario



# NEW and important from J&L STRIP STEEL DIVISION

exclusive **basic oxygen steel cold rolled strip**

## especially advantageous for deep drawing requirements

High purity, ductile, Basic Oxygen Steel is now available for the **first** time in restricted specification cold rolled strip. Low phosphorous, sulphur and nitrogen content characterize this new product. The combination of this high quality low carbon steel and the controlled processing typical of J&L's Restricted Specification Strip, results in a **new** product with many fabricating advantages. For deep drawing and intricate forming operations, superior yields and lower costs may be anticipated. The extent to which this new product may benefit your product deserves immediate investigation. Your inquiry will receive our prompt and interested attention.

**J&L STRIP STEEL DIVISION produces a full line of restricted and standard specification strip steel in these grades and types:**

| | |
|---|---|
| Low Carbon | Electrolytic Zinc, Tin, Copper & Brass Coated |
| High Carbon | Alloy |
| Tempered Spring Steel | Stainless |
| Molten Zinc Coated (Jal Zinc) | Painted |

STRIP J&L STEEL

**Jones & Laughlin**
STEEL CORPORATION
**STRIP STEEL DIVISION**
**GENERAL OFFICES: YOUNGSTOWN 1, OHIO**
**PLANTS:** YOUNGSTOWN • INDIANAPOLIS • LOS ANGELES • KENILWORTH, NEW JERSEY
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FORMERLY THE COLD METAL PRODUCTS COMPANY

to selection of film. Development techniques. *Eastman Kodak, X-Ray*

### 177. Radiography
New 18-page bulletin on gamma radiography. Uses, sources, equipment. *Nuclear Systems Div., Budd Co.*

### 178. Rust Prevention
New 16-page booklet on corrosion testing, standard rust preventives. Selection chart. *E. F. Houghton & Co.*

### 179. Rust Prevention
Nine bulletins in one folder on rust prevention. Theory of corrosion. Applications. *Production Specialties*

### 180. Rust Removal
Folder on new alkaline cleaning material for removal of rust, certain types of heat scale and metallic smuts. *Oakite*

### 181. Salt Bath Furnace
Bulletin 655 on immersed electrode salt bath furnace gives advantages, applications, construction. *Hevi Duty*

### 182. Sand Control
32-page book on defects and troubles in foundry and how to remedy them through sand control. *Claud S. Gordon*

### 183. Shotblasting
16-page "Primer on the Use of Shot and Grit". Problems of blast cleaning operations. *National Metal Abrasive*

### 184. Slitting
76-page handbook on multiple rotary slitting lines. Design, selection and operation of slitters. Specifications and capacity tables. *Yoder Co.*

### 185. Spectrographic Supplies
24-page catalog on special pure materials and alloy standards, plates and films, graphite electrodes and powders. *Jarrell-Ash Co.*

### 186. Stainless Castings
Bulletin on advantages of corrosion-resistant castings. *Ohio Steel Foundry*

### 187. Stainless Fastenings
20-page catalog of stainless steel cap screws, nuts, washers, machine screws, sheet metal screws, set screws, pipe fittings and specialties. *Star Stainless Screw*

### 188. Stainless Steel
New data sheets covering 17 types of stainless steels. Chemical composition, applications, processing, physical and mechanical properties, machining, forming, welding. *Jones & Laughlin*

### 189. Stainless Steel
Two booklets on 200 series of low nickel, austenitic stainless steels, give applications and properties compared with 300 series. *Republic Steel*

### 190. Stainless Steel
Booklet on 430 stainless. Properties, fabrication. *Sharon Steel*

### 191. Steel
256-page handbook lists sizes, weights, lengths, steels available, shapes. Data on mechanical properties, standard steel compositions, hardness numbers conversions. *Ryerson*

### 192. Steels
New 40-page booklet on investment-cast properties of 8 stainless and 4 low-alloy steels. Chemical compositions, applicable AMS specifications, mechanical properties. *Haynes Stellite*

### 193. Sub-Zero Treatment
New 10-page bulletin on industrial chilling equipment for shrinking, testing and treating of metals. *Cincinnati Sub-Zero Products*

### 194. Surface Measurement
New Bulletin LT24 on instrument to measure surface roughness and waviness. Used on metals, plastics, ceramics. *Micrometrical Mfg. Co.*

### 195. Temperature Measuring
8-page catalog 175 on optical, micro-optical, radiation, immersion and surface pyrometers. *Pyrometer Instrument Co.*

### 196. Tempilstiks
Folder 571 on Tempilstik, pellets and Tempilaq, temperature indicating devices. *Tempil® Corp.*

### 197. Testing Machines
12-page catalog on ten testers including hardness, ductility, tensile, compression and transverse strength. *Detroit Testing Machine*

### 198. Testing Machines
New 28-page Catalog No. RU-4-57 on screw power universal testing machines and accessories. Construction, specifications. *Riehle*

### 199. Testing Machines
New 8-page Bulletin RG-14-55 on testing machines and instruments. *Riehle*

### 200. Thermocouples
New 28-page catalog describing complete line of miniature thermocouples. Uses, calibrations, temperature ranges, materials of construction. *Thermo Electric*

### 201. Thickness Gage
Folder on pocket-size gage. How to use it. *Ferro Corp.*

### 202. Thickness Tester
Data sheets give ranges, principle of operation of nondestructive thickness tester. *Unit Process Assemblies*

### 203. Tin News
Interesting monthly report covers important current developments in the production, marketing and use of tin. *Malayan Tin Bureau*

### 204. Titanium
New 32-page Titanium Engineering Bulletin No. 6 on titanium welding techniques. Procedures, mechanical properties of weldable grades. *Titanium Metals Corp. of America*

### 205. Titanium Alloy
Data sheet on MST 6Al-4V high temperature titanium alloy. Creep and fatigue properties. *Mallory-Sharon Metals*

### 206. Titanium Powders
Data on high purity and commercial titanium powders. *Hawkridge Metals.*

### 207. Tukon Tester
New 12-page Bulletin DH-328 on Tukon micro and macro hardness testers. *Wilson Mechanical Instr.*

### 208. Ultrasonic Cleaning
New 24-page Bulletin S-200 explains practical applications and basic principles of ultrasonic cleaning. Design of equipment. *Branson*

### 209. Vacuum Furnace
New Data Sheet 660 on a vacuum melting furnace with melt capacity of 50 lb. *F. J. Stokes*

### 210. Vacuum Melting
New bulletin on vacuum melting furnaces which can be used in production or laboratory. *Zak Machine Works*

### 211. Vacuum Valves
New 32-page manual on high-vacuum valves. Requirements for high-vacuum service, sizes, materials. *NRC Equipment*

### 212. Vanadium in Steel
189-page book on properties of ferrous alloys containing vanadium and their applications. *Vanadium Corp.*

### 213. X-Ray
12-page bulletin on gamma radiography tells how to select the source, equipment, techniques and fundamentals of gamma radiation. *Picker X-Ray*

### 214. Zinc Coating
New 8-page booklet on zinc-coated steel sheets. Fabrication, uses, advantages in heating, ventilating and air conditioning. *Weirton Steel*

July, 1958

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|---|---|---|---|---|---|---|---|---|---|---|
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| 4 | 24 | 44 | 64 | 84 | 104 | 124 | 144 | 164 | 184 | 204 |
| 5 | 25 | 45 | 65 | 85 | 105 | 125 | 145 | 165 | 185 | 205 |
| 6 | 26 | 46 | 66 | 86 | 106 | 126 | 146 | 166 | 186 | 206 |
| 7 | 27 | 47 | 67 | 87 | 107 | 127 | 147 | 167 | 187 | 207 |
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| 17 | 37 | 57 | 77 | 97 | 117 | 137 | 157 | 177 | 197 | |
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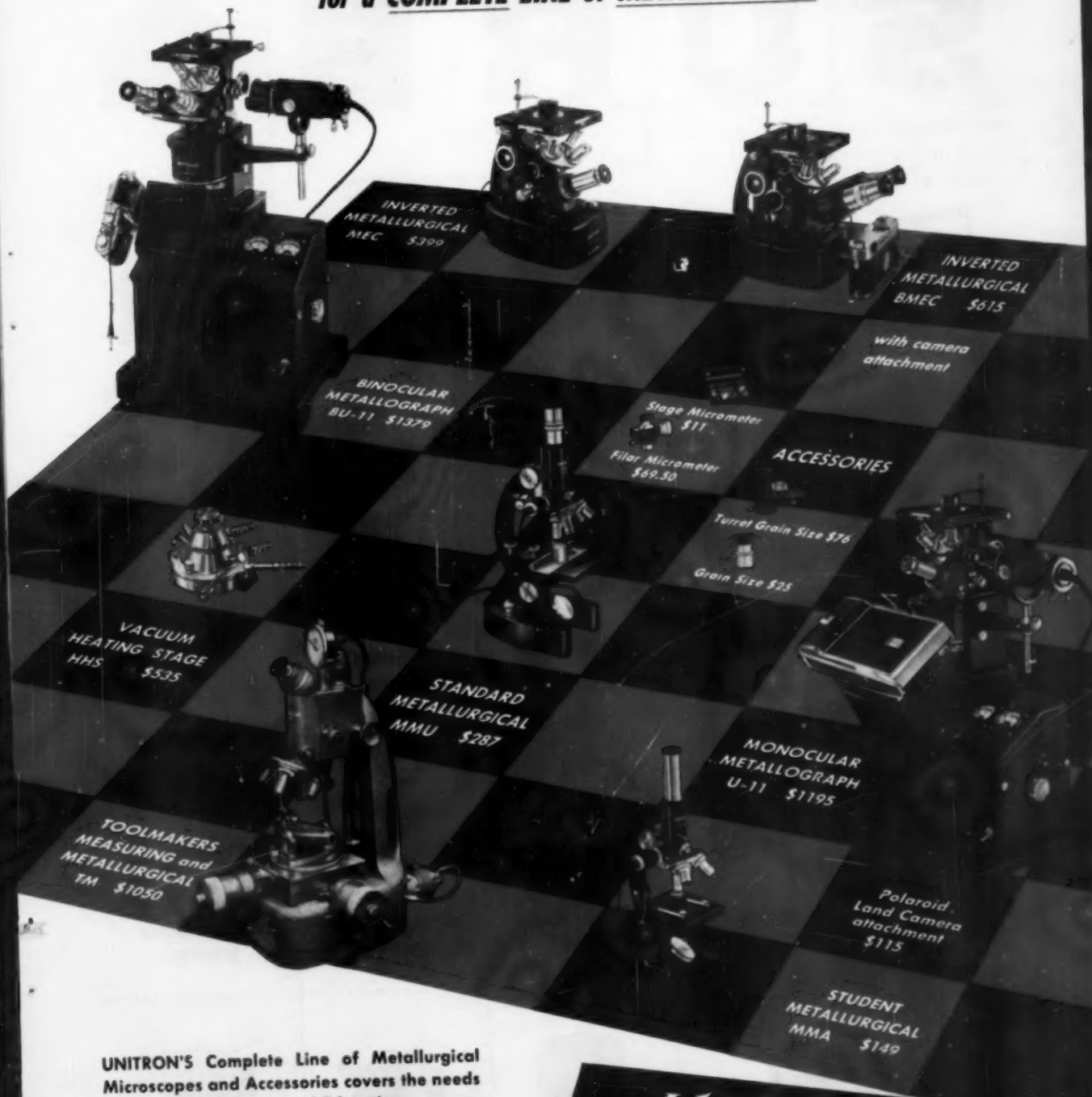


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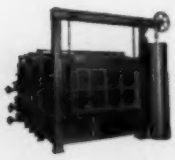
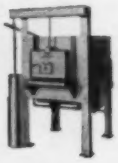
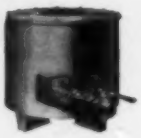


large oven



small oven

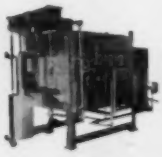
laboratory



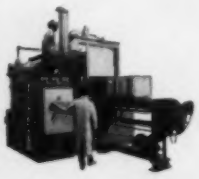
circular pot

rectangular pot

forge



balco® atmosphere

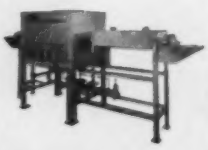


allcase® atmosphere

horizontal muffle

vertical muffle

brazing



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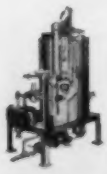
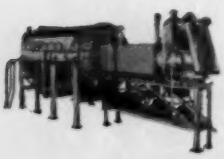


MRX® atmosphere generator

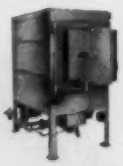
MDX® atmosphere generator

MAX® atmosphere generator



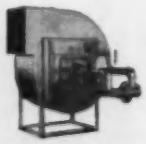
stainless steel

rivet heater



horizontal convection

vertical convection



direct air heaters

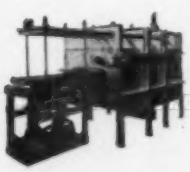
# C E

tilting metal melting

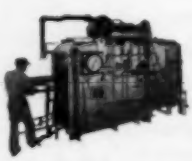
stationary metal melting

soft metal melting

aluminum melting-holding

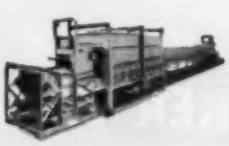


continuous snap hearth



continuous link belt

indirect air heaters



continuous brazing

## *widest selection*

The Surface line of Standard Rated equipment offers a broad range of types and sizes to choose from. Exactly what is needed can be selected. Standard furnaces can be modified to meet the demands of unusual applications.

## *known production rates*

Rated production makes it easy to determine the quantity of finished product which a Surface unit will produce in any given period of time.

## *known operating costs*

Tabulated figures and performance curves on all units clearly indicate in advance the operating cost per pound of finished product.

## *quick delivery*

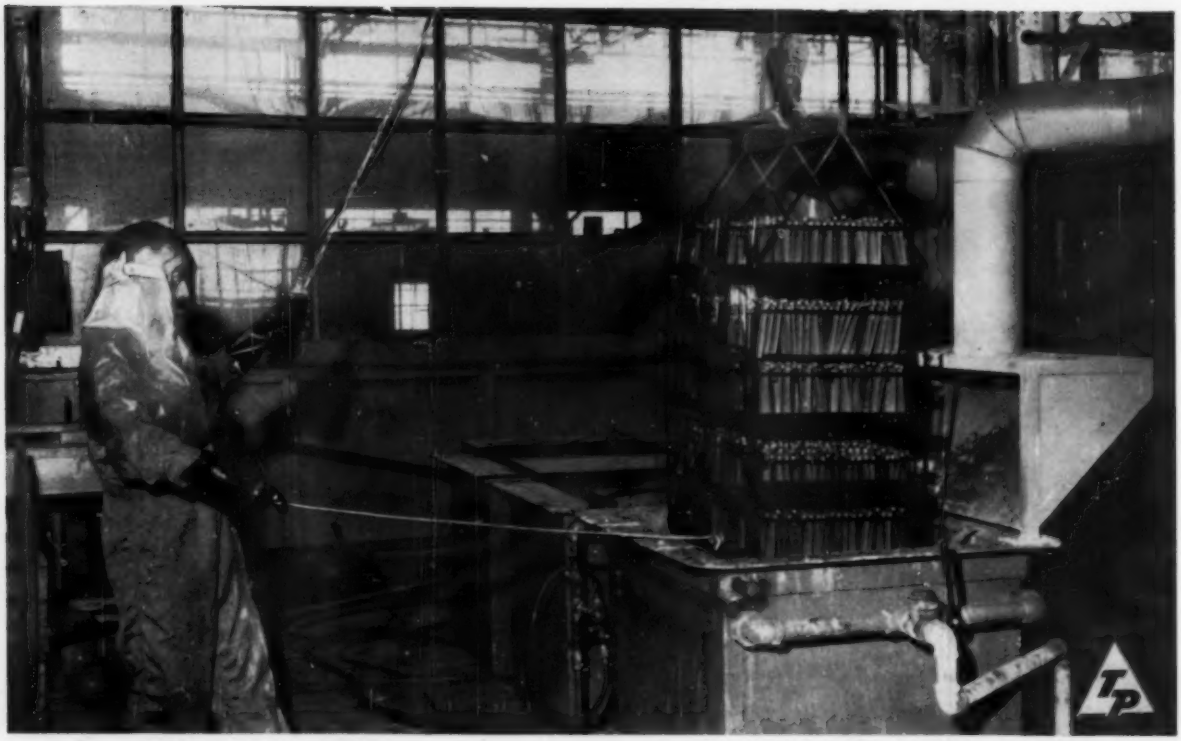
Surface standardization permits stocking the same parts for many different furnaces. This cuts engineering and procurement time. Surface also offers 80 types and 800 sizes of industrial burners—the same as used on Standard Rated furnaces—for application to your existing furnaces or other requirements.

*Write for Bulletin SC-175.*

**Surface Combustion Corporation**
2377 Dorr Street, Toledo 1, Ohio. In Canada: Surface Industrial Furnaces, Ltd., Toronto, Ont.

Surface

*wherever heat is used in industry*



# How Thompson Products saves $9,750 a month descaling titanium parts in hot Virgo bath

In this plant of Thompson Products, Inc., titanium forgings become mirror-smooth blades for aircraft turbines. But first, workers must get rid of the tough black oxide scale that forms on the parts during forging and heat treating.

They used to *blast* scale loose with a special zirconium sand imported from half-way around the world. But the sand was expensive—$10,000 a month. It had to be purchased and stored 4½ carloads at a time. Stacked in bags, it ate up valuable space—and made a mess when heavy bags burst.

Then this company called in a Hooker sales-service man who showed how they could get the scale off *chemically*. He recommended Virgo Descaling Salt at a cost of only *$250 per month* instead of $10,000 for sand.

**Parts come clean in 4 dips**

Now titanium parts ride in stainless-steel baskets through four dip tanks—and come out with not a trace of scale. In five minutes in the first tank, molten Virgo salt at 850°F removes almost all of the stubborn scale. In successive dips, cold water removes the adhering molten salt, acid quickly removes the residual soft oxide and hot water rinses the parts clean.

The process descales stainless steel and other high-temperature alloys, too—simply by raising temperature of the salt another 100 degrees. There's no attack on the metal itself at any stage.

It's easier now for inspectors to see tiny defects in the smooth, chemically clean surface of these parts; so quality control is better than before.

Maintenance costs are lower, too: just four dip tanks that need occasional replenishing with salt and acid.

Have you a tough scale problem? Perhaps a talk with a Hooker representative will open a way to substantial cost reductions for you. If you'd like to discover how, just drop us a note on your business letterhead.

**HOOKER CHEMICAL CORPORATION**
*407 Union Street, Niagara Falls, N. Y.*

HOOKER CHEMICALS PLASTICS

DUREZ® PLASTICS DIVISION • NORTH TONAWANDA, N.Y.
NIALK® CHEMICALS • NIAGARA FALLS, N. Y.
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*Sales Offices:* Chicago, Ill.; Los Angeles, Calif.; New York, N. Y.; Niagara Falls, N. Y.; Philadelphia, Pa.; Tacoma, Wash.; Worcester, Mass. *In Canada:* Hooker Chemicals Limited, North Vancouver, B. C.

# 60 CYCLE INDUCTION MELTING

A famous metallurgist once wrote: "50% of all rejects can be traced to faulty melting and pouring." When molten metal is overheated, important alloy ingredients are lost by burning. Castings or billets may be porous from combustion gases absorbed by the molten metal. Frequently, unwanted alloy ingredients are picked up from the containers used in melting. If the temperature of molten metal flowing into a mold strays from the optimum, defective castings will result. In a quiet melt alloy ingredients may not dissolve properly, and the metal cast will not meet specifications. Finally, there is the problem of nonmetallics suspended in the melt which cause occlusions and other difficulties in the end product.

60 CYCLE INDUCTION MELTING, properly applied, is probably the biggest single step that can be taken to overcome these traditional melting problems. The method is unique in its combination of two factors: Heat is generated only in the molten metal, and the entire melt is stirred by electromagnetic pressure. Furthermore, high melting rates can be concentrated in a small space. —No part of the furnace is hotter than the metal. Combustion gases are absent and controlled atmospheres can be used. The container is constructed of refractories inert to the molten metal. Temperature control of unprecedented precision is inherent in the method. Electromagnetic stirring assures complete dissolving of all ingredients and a uniform alloy. Suspended nonmetallics are deposited in the electromagnetic pressure area.

These are basic reasons why 60 CYCLE INDUCTION MELTING has had such a spectacular growth in the postwar period. Modern plants require high production rates with controlled quality, yet can assign only a minimum of skilled labor to each operation. 60 CYCLE INDUCTION MELTING minimizes hard labor in melting. It enables process control to substantially decrease the effect of human error. Cost reductions are reflected throughout each step of fabrication of a casting or billet to its end use.

60 CYCLE INDUCTION MELTING, firmly established for thirty years as the predominant production method for melting brass, has recently been applied on a much larger scale. In the last ten years, as new furnace designs became available, the method has been rapidly adopted by many progressive companies in the fields of aluminum die casting, aluminum extrusion, aluminum wire, aluminum coating, leaded copper alloy casting, zinc die casting, and galvanizing of strip in the steel mills. Well over one thousand 60 CYCLE INDUCTION MELTING furnaces are now operating in these new fields.

Our 60 CYCLE INDUCTION MELTING furnace takes many different forms to meet the needs of all these industries. Unit production rates now range from 150 pounds to 40 tons per hour. We specialize in the development, design, and manufacture of standard and custom-built furnaces to meet each requirement. If there is a production melting problem in your operation which may benefit from a basic change in method, we should be glad to discuss the possibilities with you.

**ajax**

**ENGINEERING CORPORATION**

TRENTON 7, NEW JERSEY

Associated Companies: Ajax Electric Company Ajax Electrothermic Corp.

# ALUMINUM ANODIZED

## Curtain Going Up!

The Marion Davies Building, New York, was completely enclosed in *10 hours*—through the miracle of anodized aluminum "curtain" walls. Giant two-story panels are manufactured by General Bronze Corp., using an **H-VW-M AUTOMATIC ANODIZING SYSTEM.**

General Bronze Corp. led the field when they anticipated the vastly increased use of anodized aluminum in the building industry. The same wisdom and foresight motivated General Bronze when they called on H-VW-M to supply their giant, streamlined new anodizing system. **H-VW-M DESIGNED, MANUFACTURED AND INSTALLED** it from beginning to end. And the benefits to General Bronze: tripled production . . . improved quality control . . . and the assurance that H-VW-M—the **ONE SOURCE** they chose—assumed **COMPLETE RESPONSIBILITY** for the entire system, from concept to production. **Hanson-Van Winkle-Munning Co., Matawan, New Jersey. Offices in principal cities.**

3114

# H-VW-M

Industry's Workshop for the Finest in Plating, Anodizing, and Polishing Processes • Equipment • Supplies

***PLATEMANSHIP*** —Your H-VW-M combination—of the most modern testing and development laboratory—of over 80 years experience in every phase of plating and polishing—of a complete equipment, process and supply line for every need.

# Solution Heat Treating Aluminum Parts at DOUGLAS AIRCRAFT in *NEW* DESPATCH Bottom-Entry (*elevator type*) FURNACE

● **±4°F. Temperature Uniformity** in the work chamber of this Despatch (bottom-entry) furnace is maintained in production at 1000°F. temperature at Douglas Aircraft Company, Long Beach, California. The furnace is one of the tallest elevator type constructed 37 feet 8 inches overall permitting a work chamber large enough to solution treat large aluminum wing and fuselage components. The work chamber measures 13′ x 6′ x 24′, can handle 600 lbs. of aluminum and can bring a cold load to temperature in 15 minutes.

The special Despatch design will move the load after the heat cycle is completed to the quench tank placed below loading level in 5 seconds.

**Automatic Operation from loading to quench**—Although this Despatch furnace is completely automatic, it can be manually operated if desired. Automatic operation is begun with the elevator at floor level. Regulation of the elevator power, with door operation in-and-out of heat zone and in-and-out of quench tank assures perfect cycling through the solution heat treating, quenching program ±4°F.

**Close Temperature Control** is maintained with use of Brown controller and a G.E. saturable core reactor system.

850 kw of 440-v, 3-phase 60-cycle power attain the furnace temperature. Half of the current is from the G.E. reactor and the other half from conventional contactors.

Thermocouples near the furnace supply duct checks temperature of air entering the work chamber. Both the flow and quantity of the incoming air is regulated to assure temperature uniformity throughout the heat chamber.

**Despatch engineers are pioneers** in designing aluminum solution heat treating furnaces. They have developed many designs for controlling heat in work areas of all sizes and shapes. From half a century of experience in heat treatment of both ferrous and non-ferrous metals in the heat range to 1550°F. Despatch can provide helpful solutions to your heat treating problems.

**Write today for bulletin No. 81P** for a complete report on the range of Despatch furnaces for metalworking industries.

DESPATCH OVEN COMPANY

PIONEERS IN ENGINEERING HEAT APPLICATIONS FOR INDUSTRY

XXVII

*This is the twenty-seventh of a series of advertisements dealing with basic facts about alloy steels. Though much of the information is elementary, we believe it will be of interest to many in this field, including men of broad experience who may find it useful to review fundamentals from time to time.*

# Cold-Finishing of Alloy Steels: The Effect of Cold-Drawing

The cold-drawing of alloy bars was discussed in the advertisement prior to this one, No. XXVI in the series. Here, we continue with a general explanation of the effect of cold-drawing.

During the cold-drawing process, certain changes take place in the steel structure, and in mechanical properties. There is a slight increase in tensile strength, compared with a substantial increase in yield point, and a decrease in ductility. These properties enable the production of small parts which require the greater strength necessary for certain automatic-machine forming operations, and a machine finish superior to hot-rolled material. Naturally, the beneficial effects of alloy steels are attained in the subsequent heat-treatment of parts.

The process of cold-drawing results in bars which are free from scale, accurate to shape, and within close tolerances. These conditions are ideal for automatic machining, as the elimination of scale is conducive to long tool life, and the accuracy of shape and close tolerances permit the bars to pass freely through the feed mechanism of the "automatic." Moreover, the cold-drawn finish and tolerances may be such that machining can be eliminated in some areas of the finished part. For example, sparkplug shells are produced from hexagon bars which require no machining on the hexagon sections.

Continuous roller hearths and car-bottom furnaces of both standard and controlled-atmosphere types, are used for special treatment of alloy bars before cold-drawing. Thermal stress-relieving can be used to reduce residual stresses in the steel caused by the cold-drawing process, wherein the mechanical properties will be altered depending upon the temperature used.

If you would like more specific details about the chemical composition or mechanical properties of cold-drawn alloy bars, and the results that can be expected, by all means consult our technical staff. Bethlehem metallurgists will gladly help you work out any problem, without cost or obligation on your part.

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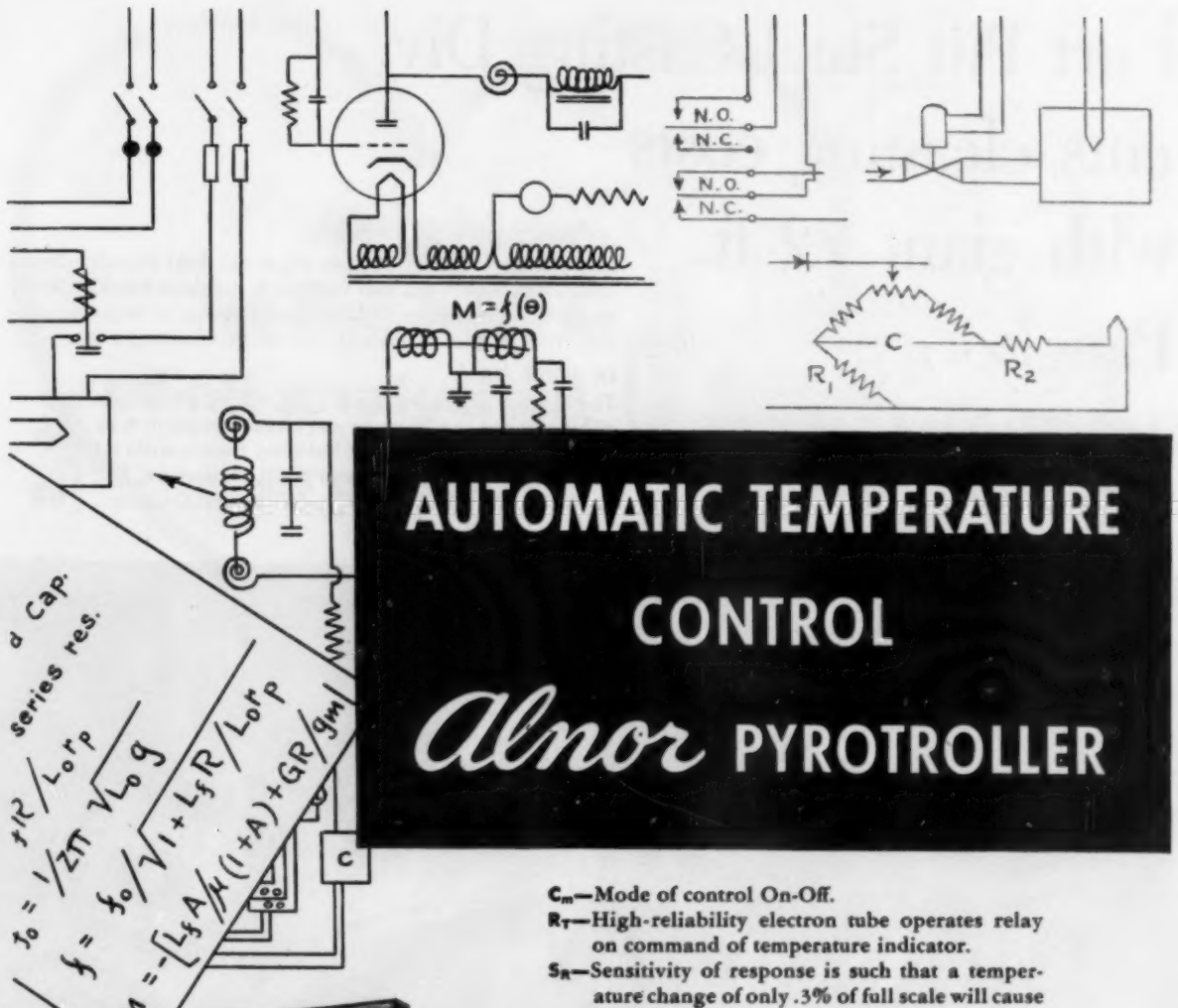


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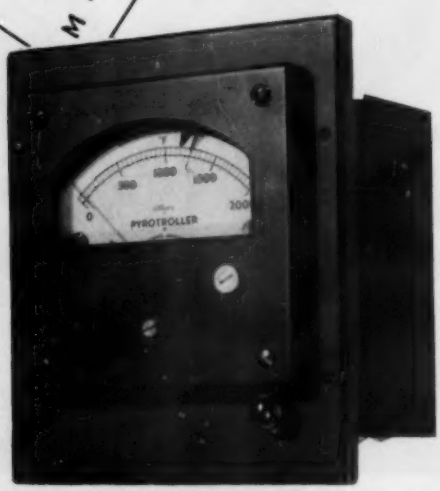


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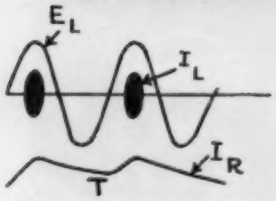


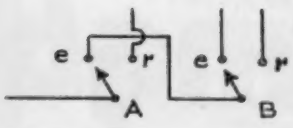


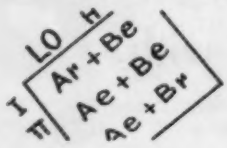


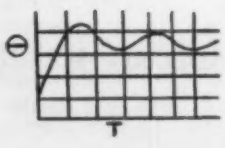

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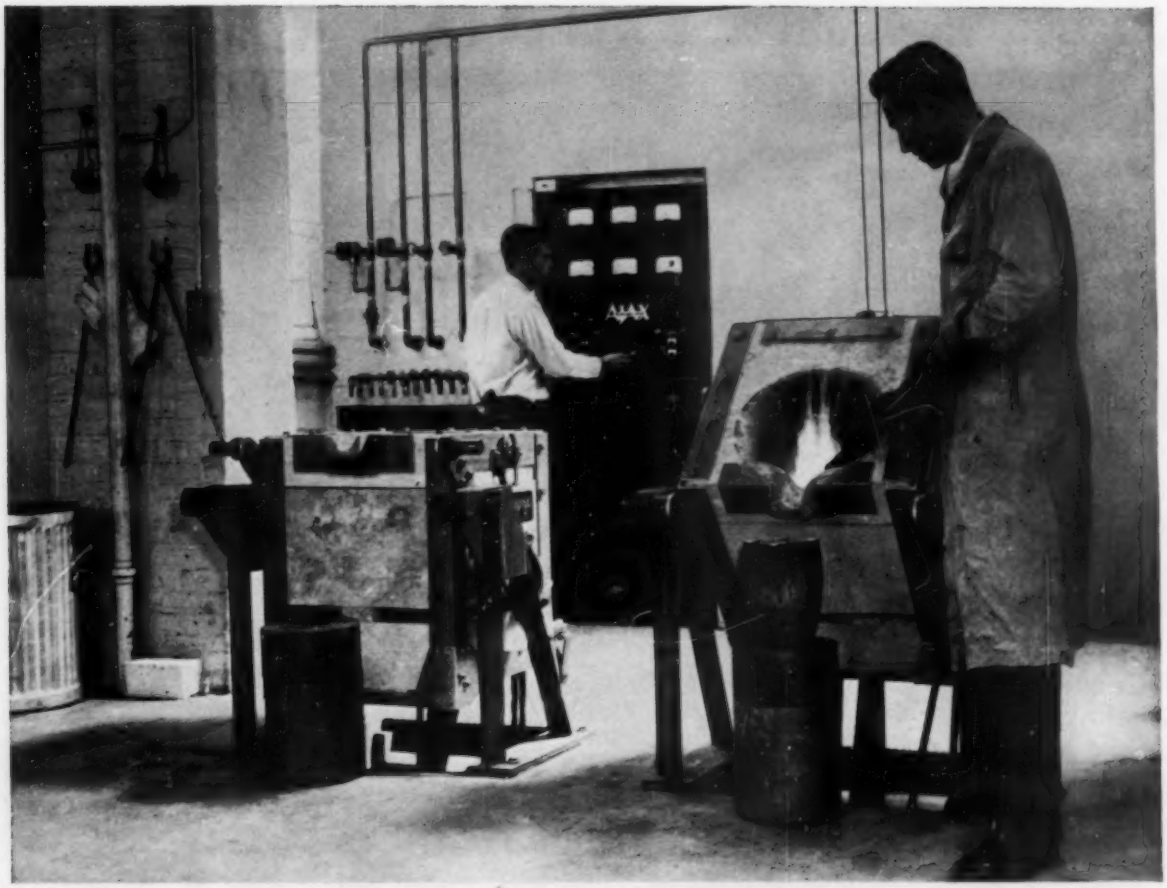


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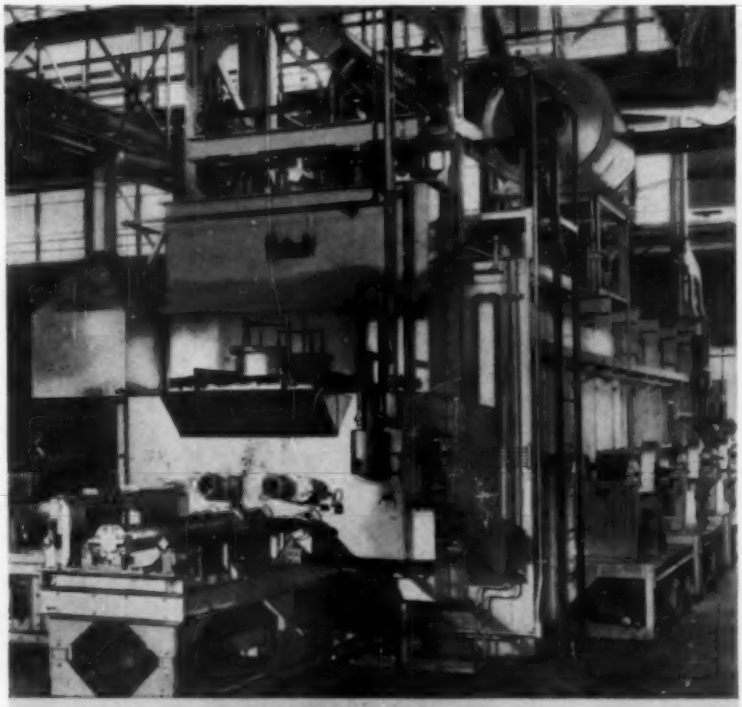

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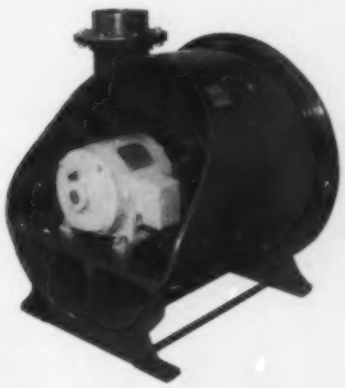

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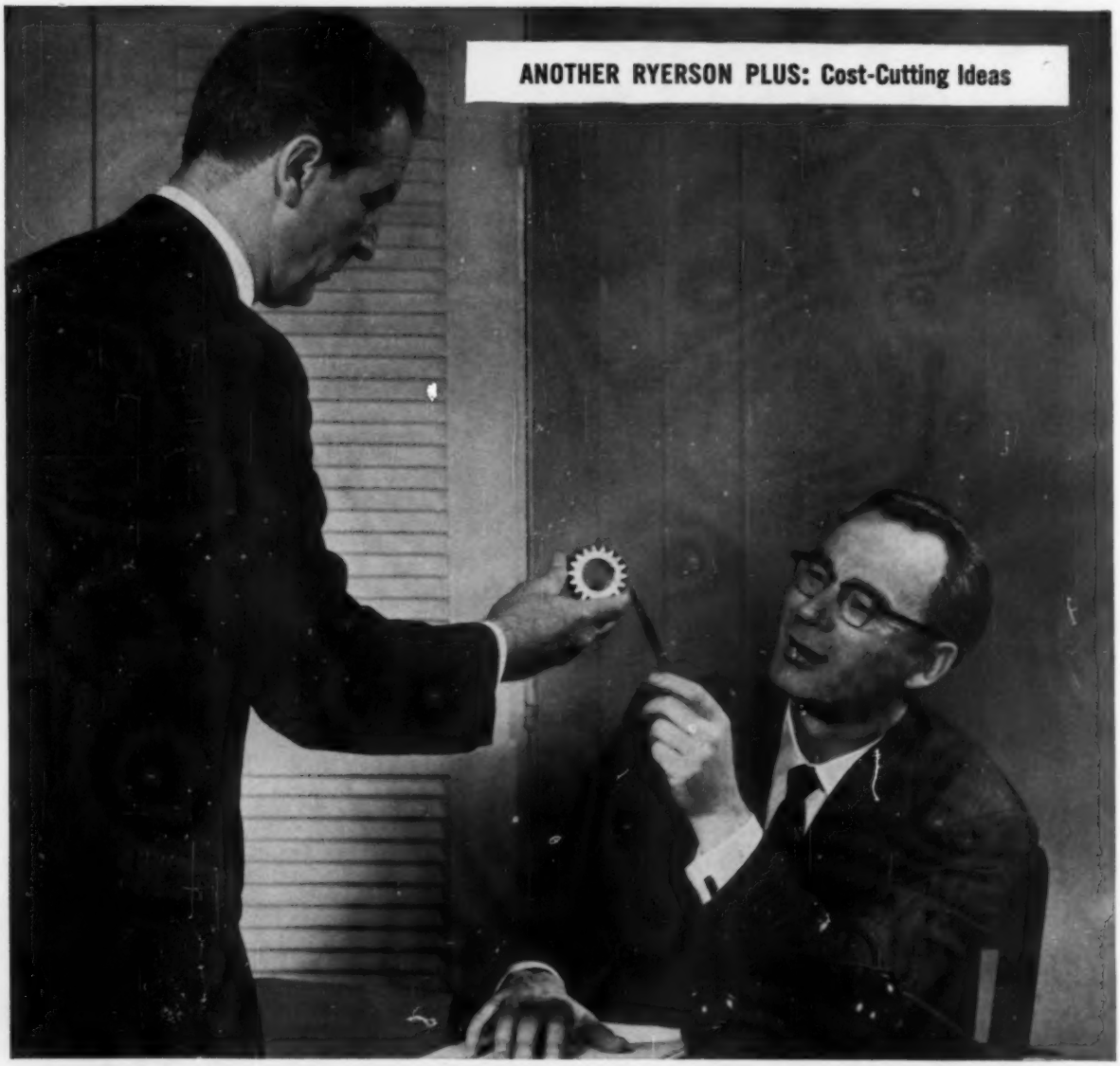


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# *Preparation of Arc-Melted Uranium Carbides*

*By R. J. GRAY, W. C. THURBER and C. K. H. DuBOSE**

**Uranium carbides are promising materials for aluminum reactor fuel elements requiring high uranium investments — particularly for the Atoms-for-Peace Program, where the $U^{235}$ enrichment is limited to 20%. Aluminum-uranium carbide fuel plates, fabricated by the picture-frame technique, retain their dimensional tolerance during heat treatment. Microstructures in color (see cover) and in black and white were studied in detail.**
**(M27d, M21, T11g, 17-57; U, 14-68)**

*R. J. Gray is head of Metallography Laboratory, W. C. Thurber is head of Alloy Preparation Laboratory, and C. K. H. DuBose is metallography technician, Oak Ridge National Laboratory, Oak Ridge, Tenn. Acknowledgment is made to J. B. Flynn, J. Richter and W. Laing for alloy preparation, X-ray determinations and analytical chemistry work, respectively.

MANY OF THE RESEARCH REACTORS in operation in the U.S. today are powered with highly enriched fuel, which contains upwards of 90% $U^{235}$. This fuel is incorporated in the reactor core in the form of extremely thin, alclad uranium-aluminum alloy plates. The composite fuel plates are assembled by brazing into a component of the type shown in Fig. 1. This type of fuel element design, which has been successfully used in the Materials Testing Reactor (MTR) for the past six years, has a high surface-to-volume ratio. Such elements can operate at a high power density and at the high flux levels required for irradiation testing of materials.

Limiting the enrichment of fuel for export under the Atoms-for-Peace Program imposes serious fabrication problems if the uranium-aluminum alloys used in MTR-type fuel elements are considered as the fuel core. Under this program, the 10 to 20 wt.% uranium core, with a high enrichment of $U^{235}$, must be replaced with a core containing about 50% uranium, enriched only 20% in the $U^{235}$ isotope to achieve the same loading of fissionable material. An alloy containing this much uranium would evidence considerable segregation and would not lend itself to the picture-frame technique (illustrated in Fig. 2) for plate fabrication. In this fabrication method, an alloy or a pressed powder core of a uranium compound dispersed in an aluminum matrix, is encased in wrought aluminum frames and cover sheets. The encasement is then rolled to the desired dimensions to obtain the finished plate.

The high density of the uranium carbides (11.7 to 13.6 g. per cc.) makes these ceramics attractive as fuel materials for reactor designs requiring a high uranium investment. They also can be adapted to the picture-frame technique for fuel plate fabrication using powder metallurgy processing methods. For these reasons, it was considered important to study the use of uranium carbides as a fuel material.

## Preparation of Carbides

Three uranium carbides have been reported for this binary system: the monocarbide (UC) containing 4.80 wt.% C; the sesquicarbide ($U_2C_3$) containing 7.04% C; and the dicarbide ($UC_2$) containing 9.16% C. The sesquicarbide cannot be produced directly; it requires a

Table I – Physical Properties of Uranium Carbides

| Compound | Color | Density* | Melting Point | Crystal Structure | Lattice Constants† | | Pyrophoric |
|---|---|---|---|---|---|---|---|
| | | | | | $a_o$ | $c_o$ | |
| UC | Metallic | 13.63 | 2250° C. | f.c.c. | 4.951 | — | Yes |
| $U_2C_3$ | Metallic | 12.88 | 2350-2400 | b.c.c. | 8.088 | — | ? |
| $UC_2$ | Metallic gray | 11.68 | 2350-2400 | b.c.t. | 3.517 | 5.987 | Yes |

*From lattice parameter measurements, g. per cc. †In Angstrom units.

slight amount of stressing to initiate formation from a mixture of UC and $UC_2$.* It is not often encountered in materials prepared by conventional practices and was not studied in this investigation. Physical properties of these materials are given in Table 1.

*"Uranium Sesquicarbide", by M. W. Mallet, A. F. Gerds and D. A. Vaughn, U. S. Atomic Energy Commission Publication, AECD-3060.

*Fig. 1 – This Fuel Element Is Made up of Thin Alclad Uranium-Aluminum Alloy Plates Which Are Assembled by Brazing Into a Component. The design (used in the Materials Testing Reactor) gives a high surface-to-volume ratio which is important in getting the high flux levels required for irradiation testing of materials. The high density of the uranium carbides makes them attractive for use in this type of reactor*

Inert-gas arc melting was used to prepare a wide range of carbides, varying in carbon content from UC to $UC_2$. Small buttons weighing about 100 g. each were prepared by melting together cleaned sheet uranium and carbon rod (spectrographic grade) in an argon atmosphere. All materials were remelted several times to insure homogeneity of the ingot. Care was taken to control the initial melting rate, to minimize carbon losses. Figure 3 shows a close-up of the furnace chamber with the water-

*Fig. 2 – The Picture-Frame Technique for Fuel Element Fabrication Can Be Used With Uranium Carbide. A pressed powder core of a uranium carbide dispersed in an aluminum matrix is encased in wrought aluminum frames and cover sheets. The encasement is rolled to the desired dimensions yielding a metallurgically bonded full plate*

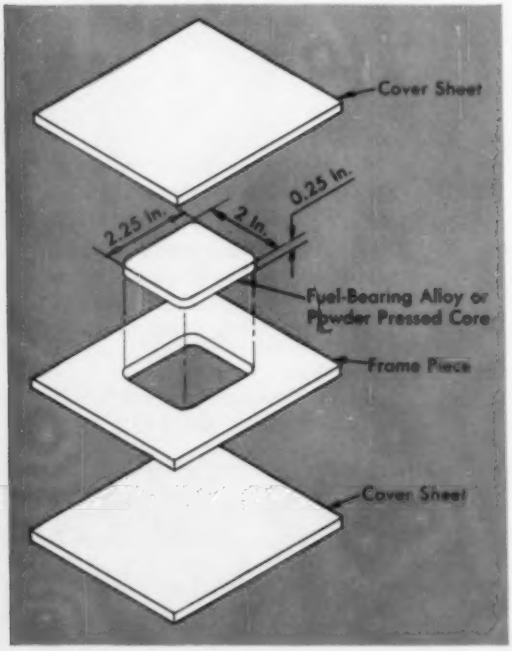


Table II – Constitution of Arc-Melted Uranium Carbides

| Carbon Specification | Analyzed Carbon Content | | | | Relative Amounts of Phases Present* | | | |
|---|---|---|---|---|---|---|---|---|
| | End 1 | Center | End 2 | Av. | $UC_2$ | UC | C | U |
| 10.00% | 9.16% | 9.59% | 9.33% | 9.36% | 80% | 5% | 15% | — |
| 9.66 | 9.02 | 9.40 | 9.18 | 9.20 | 95 | 2 | 3 | — |
| 9.16 | 9.14 | 9.08 | 9.01 | 9.08 | 95 | 5 | — | — |
| 9.16 | 8.35 | 8.17 | 8.19 | 8.24 | 90 | 10 | — | — |
| 8.00 | 7.96 | 8.02 | 7.96 | 7.98 | 80 | 20 | — | — |
| 7.04 | 6.94 | 6.96 | 6.98 | 6.96 | 50 | 50 | — | — |
| 6.00 | 5.64 | 5.74 | 5.86 | 5.75 | 10 | 90 | — | — |
| 4.80 | 4.82 | 4.88 | 4.88 | 4.86 | 10 | 90 | — | — |
| 4.30 | 4.61 | 4.56 | 4.22 | 4.46 | — | 99 | — | 1 |

*From X-ray intensities.

cooled, tungsten-tipped electrode used in the melting operation.

Table 2 gives the constitution of several arc-melted carbides containing from 4.5 to 9.4% C. The data indicate that reasonable homogeneity was achieved and that in general, carbon losses were not severe. Information on the relative amounts of the various phases present, based on X-ray line intensities, is also given. These X-ray data are semiquantitative at best and serve primarily as a guide in interpreting the microstructures of the carbides.

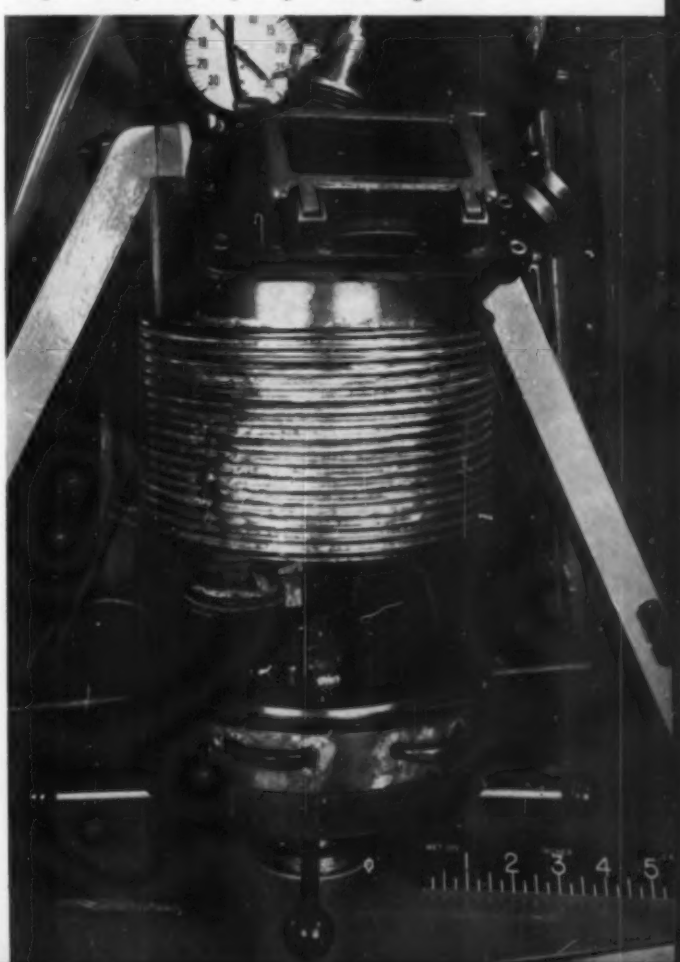
## Metallography

Specimens were mounted in a conventional bakelite mount and rough-ground on a flat, 240-grit diamond wheel at 250 rpm., using kerosene as a coolant. The next two polishing steps involved canvas-covered wheels operating at 250 rpm., using 30 to 40-micron and 4 to 8-micron Elgin Dymo diamond paste, respectively. Elgin Dymo thinner, an oil specifically designed for the paste, was used for lubricating and cooling the specimen. A metallographic polishing cloth (Gamel or Microcloth) was used next, employing 0 to 1-micron diamond paste with the lubricating oil.

The same type of metallographic polishing cloth was also used in the next two steps with 0.3-micron and 0.1-micron alumina, respectively. The lubricating oil designed for the diamond paste was used with the alumina. The final polishing operations were conducted with only about 10-sec. periods on the polishing wheels in order to reduce relief polishing. Water was avoided in all specimen polishing and cleaning, due to the tendency of all the uranium carbides to hydrolyze, resulting in nonuniform staining of the specimens.

**Etching** – Although some revelation of microstructures could be achieved by etching with water, this procedure did not disclose the microstructure as well as did an etchant consisting of equal parts of glacial acetic acid, concentrated nitric acid and water. The specimen was immersed in the etchant, at room temperature, for 10 to 50 sec. The longer etching time was

*Fig. 3 – Close-Up of Furnace Chamber and Water-Cooled Copper Hearth Used in Melting Uranium-Carbon Alloys. Samples are melted in argon atmosphere; they weigh about 100 g. each*



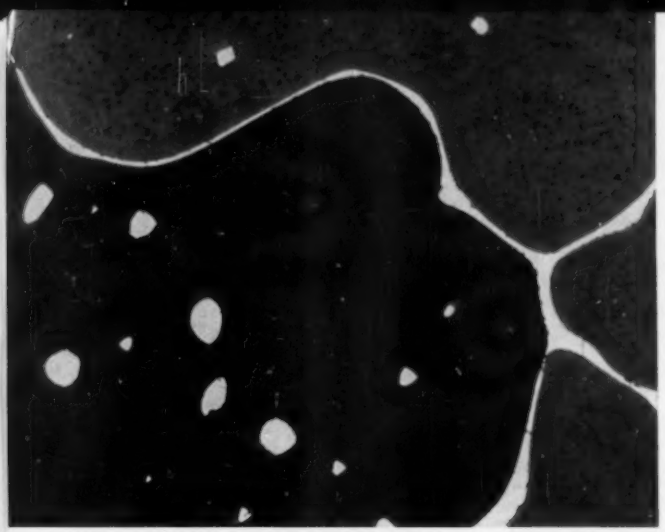


*Fig. 4 – Uranium-Carbon Alloy (4.46% C) Composed of 99% UC With 1% Alpha Uranium. The light phase at grain boundaries and in globules is alpha uranium (1000 ×)*

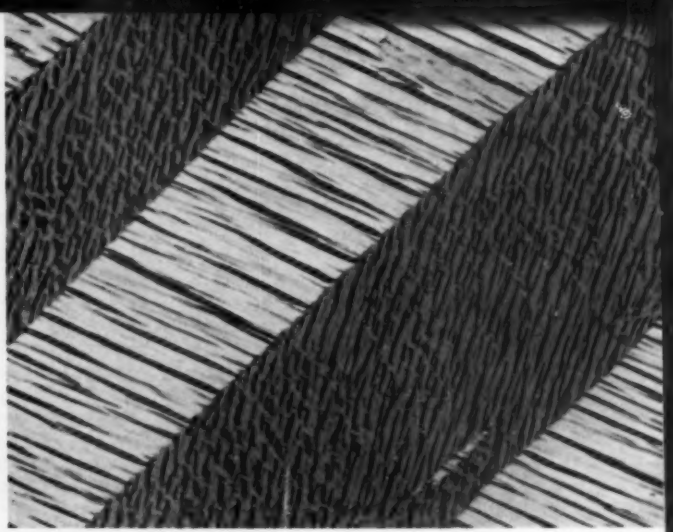


*Fig. 7 – Uranium-Carbon Alloy (7.98% C) Composed of 80% $UC_2$ and 20% UC. The dark Widmanstätten precipitate is UC (1000 ×)*

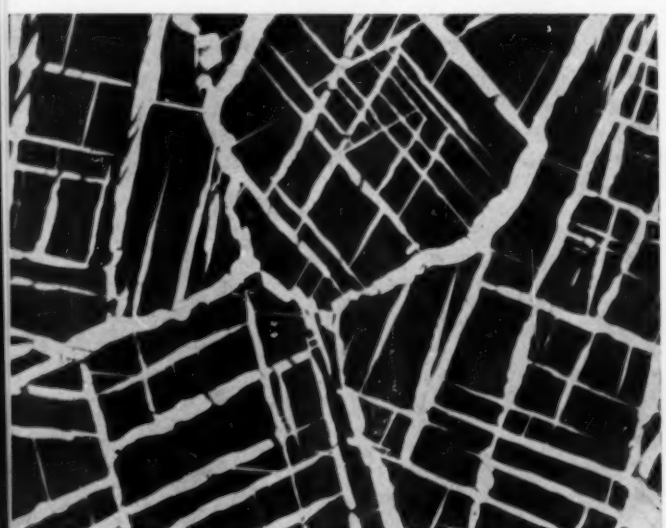


*Fig. 5 – Uranium-Carbon Alloy (5.75% C) Composed of 90% UC With 10% $UC_2$. The light Widmanstätten structure is $UC_2$ (1000 ×)*

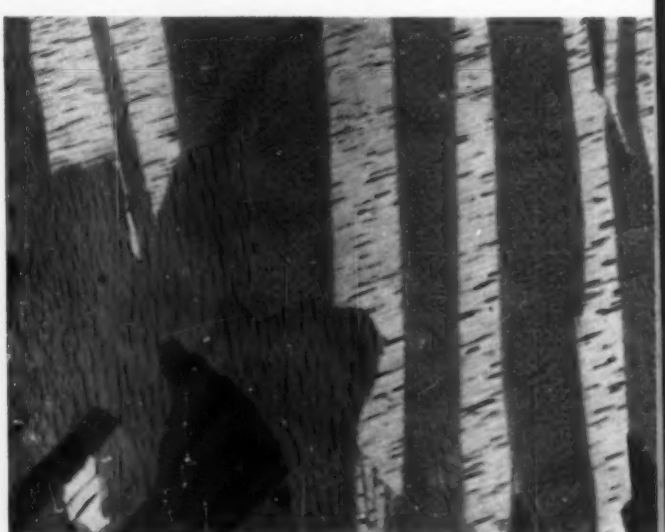


*Fig. 8 – Uranium-Carbon Alloy (8.24% C) Composed of 90% $UC_2$ and 10% UC. The dark precipitate is UC (1000 ×)*

*Fig. 6 – Uranium-Carbon Alloy (6.96% C) Composed of 50% UC and 50% $UC_2$. The dark phases are UC; the white ones are $UC_2$ (1000 ×)*

*Fig. 9 – Uranium-Carbon Alloy (9.20% C) Composed of 95% $UC_2$, 3% Graphite, and 2% UC. UC is not obvious in this structure. Dark flakes are graphite (1000 ×)*

*Fig. 10 – Transverse View of Fuel Plate With Uranium Carbide-Aluminum Core. It was fabricated by rolling and annealing using the picture-frame technique (75×)*

needed with alloys of higher carbon content. The effect of the etchant was to form an interference film on the surface of the sample which varied in color with the orientation of each grain. The color variations were equally distinct with either bright field illumination or polarized light. Because of the contrasting colors, photomicrographs could be made in black and white or in true color with color film. The cover shows photomicrographs made in color at 50× magnification using bright-field illumination. (Also, see box, p. 70, for description of samples.)

**Photomicrography** – Black and white photomicrographs were made with Super Panchro-Press type B film, using DK-50 1:1 developer. Color photomicrographs were made with Ektachrome Daylight film, with a carbon-arc light source. A sodium nitrite solution was used in the water cell for filtering out excess ultraviolet light to obtain the desired color balance in reproducing the true color of the specimen.

The microstructure in black and white (1000×) of the 4.46% C ceramic alloy is shown in Fig. 4. X-ray intensity measurements showed that the structure had 99% UC and 1% alpha uranium. The alpha uranium is the white phase at the grain boundaries and in isolated small and large globules; the matrix is UC.

An alloy with 5.75% C is shown in Fig. 5. This structure was analyzed by X-ray and found to contain 90% UC and 10% $UC_2$. The white phase at the grain boundaries and in a Widmanstätten pattern is the $UC_2$, the dark phase is the UC.

The 6.96% C alloy (shown in Fig. 6) presents a structure of 50% UC and 50% $UC_2$. It is noticeable that equal amounts of the monocarbide and dicarbide did not produce marked contrast from grain to grain. The alloy with 7.98% C is shown in Fig. 7. The microstructure is 80% $UC_2$, with 20% UC. The darker Widmanstätten structure within each grain is the UC. Increasing the carbon content to 8.24% produces a structure shown in Fig. 8. This alloy is 90% $UC_2$ and 10% UC. The UC is the fine, dark structure.

A superstoichiometric $UC_2$ is obtained with an alloy of 9.20% C, as shown in Fig. 9. Although some UC is indicated by X-ray analysis, it is not easily discernable. Some graphite flakes are shown in the microstructure, which were not evident by X-ray intensities.

Hardness measurements were attempted on all the alloys; however, only two (8.24 and 7.98%

## *On the Cover . . .*

### Color Metallography of Uranium-Carbon Alloys

This month's cover on *Metal Progress* portrays four color photomicrographs made to study structures of the uranium carbides described in this article. The etchant used formed an interference film on the surface of the sample which varied in color with the orientation of each grain. Color photomicrographs were made with Ektachrome daylight film with a carbon-arc light source. A sodium nitrite solution was used in the water cell for filtering out excess ultraviolet light to obtain the desired color balance in reproducing the true color of the specimen. Magnification is 50 × with bright-field illumination. Identity of the photomicrographs is given below:

*Upper left –*
*Alloy: 4.46 wt. % carbon*
*95.54 wt. % uranium*
*The spheroidal and grain-boundary precipitate is alpha uranium (1%); the matrix is UC (99%).*

*Lower left –*
*Alloy: 7.98 wt. % carbon*
*92.02 wt. % uranium*
*The darker almost unresolvable lamellar phase in each grain is UC (20%). The matrix is $UC_2$. Some twinning bands present.*

*Upper right –*
*Alloy: 5.75 wt. % carbon*
*94.25 wt. % uranium*
*The white Widmanstätten phase is $UC_2$ (10%). The matrix is UC (90%).*

*Lower right –*
*Alloy: 9.08 wt. % carbon*
*90.92 wt. % uranium*
*The matrix is $UC_2$ (95%). A second phase of UC (5%) is not resolvable at this magnification. Considerable twinning bands.*

C with Knoop hardness of 706 and 675, respectively) permitted hardness indentations without fracturing. The inherent brittleness of alloys containing 50% or more UC made these compositions too fracture-sensitive for hardness indentations, even with a Knoop indenter.

The tendency toward fracturing, which occurred for each alloy on standing at room temperature, correlated with the fracturing which developed in attempts to obtain hardness data. Specimens having a high UC content developed fractures within a few days. This tendency toward fracturing decreased with increasing $UC_2$ content. The polished surfaces of two alloys containing 80 and 90% $UC_2$ have not fractured after standing for several months. Apparently, hydrolysis is instrumental in fracturing; however, no tests have been conducted to determine if fracturing is reduced by a low-humidity atmosphere.

Fuel plates utilizing uranium carbide and aluminum powder as the core material have been fabricated successfully. Uranium carbide ingots made by arc melting were powdered in a rod mill. An argon atmosphere was necessary during comminution because of the pyrophoric tendencies of the uranium carbides. The picture-frame technique for manufacturing alclad fuel plates was used in making these composite plates. Figure 10 is a transverse view of a completed aluminum-uranium carbide fuel plate after rolling and annealing.

Although the uranium carbides are applicable as core material for fuel elements requiring high uranium investments, one possible detriment to the use of these materials for this purpose is their lack of corrosion resistance in aqueous environments. In the intended function of the fuel plate, the uranium carbides are encased by the picture frame and cover plates. However, exposure and catastrophic corrosion could occur in the event of a failure in the aluminum clad.

# *What the Aircraft Maker Wants in a Steel Casting*

*By L. H. McCREERY**

**The logical solution to many problems facing the manufacturer of advanced aircraft and missiles is the use of high-integrity, close-tolerance steel castings. They can be heat treated to strength levels of 180,000 psi. or more and require little or no machining. (T24a, 17-57, E-general; ST)**

FOR SEVERAL YEARS, engineers at Chance Vought Aircraft have been working to incorporate steel castings into both piloted and pilotless aircraft. The reason stems from the fact that this approach is considered necessary to support future designs. As the performance of aircraft is extended, the space available for structural components is diminished. Aerodynamic requirements dictate thinner wing sections with more pointed leading edge surfaces, and propulsion and control requirements leave practically no space for structural fittings in the fuselage. This results in fittings of extreme complexity which require maximum strength. They are not suited to forging and are costly to machine.

The logical solution to this dilemma is the use of high-integrity, close-tolerance steel castings, heat treated to strength levels of 180,000 psi. or more, which would require little or no machining. In the near future the requirements will be upgraded by the needs for resistance to corrosion, erosion and thermal shock and high hot strength. It is obvious that the tougher materials required here will increase machining difficulty and cost.

Steel castings are being used in the manufacture of aircraft and missiles at Chance Vought today:

- Seventy-two castings, including 21 ground handling items, are used in the F 8 U-1 Crusader airplane, pictured in Fig. 1. This leaves 51 airframe castings. Materials employed include Type 410, 17-4 and 347 stainless steel and 4130, 4140, 4330 and 4340 alloy steels.
- Fifty-seven steel castings are used in the Regulus II missile (Fig. 2), of which five are ground handling items and four are expendable launching parts. Many are in the "larger than investment" category. In many of the fork-type castings cast-in tie bars are needed.
- Ninety-five steel castings, including ground handling items, are predicted for the F 8 U-3. This does not include any of the large future design castings. Several applications have been discarded as being ahead of the state of the art.

To satisfy the desires of the aircraft maker, we must explore four factors associated with successful utilization of steel castings in airframe

*Supervisor, Engineering Structures Materials, Chance Vought Aircraft, Inc., Dallas, Tex.

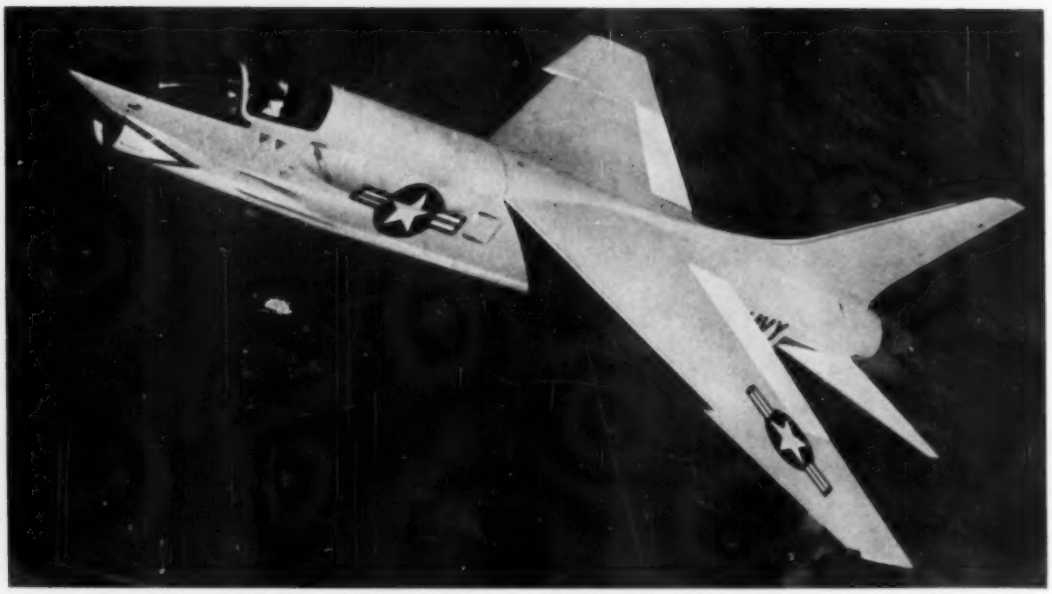


*Fig. 1 – Fifty-One Steel Castings Are Used in the Airframe of the F 8 U-1. Some 21 castings are used in ground handling items*

manufacture: (*a*) accuracy and precision of configuration; (*b*) inherent quality; (*c*) ability to perform; and (*d*) reliability of delivery.

**Accuracy** – First, the aircraft manufacturer must know that he can get a steel casting made to a designated configuration with the dimensional accuracy specified. Now why does he have to be so picky in this area? It's very simple: The casting specified has to do a given job within a specified space. Progress in performance of aircraft has meant thinner wings, with the fuselage packed with more engine, fuel and auxiliary equipment. This progress results in more load to be carried by the frame or structure in less space. The configuration generally must be provided as specified and with the required dimensional accuracy if it is to perform its duty in the limited space allowed. Figure 3 shows a selection of steel castings for aircraft use made by the various processes. The launching frame casting for Regulus II shown in Fig. 4 is made of 4330, weighs 285 lb. and has a minimum tensile strength of 150,000 psi.

*Fig. 2 – Fifty-Seven Steel Castings Are Used in the Regulus II Missile of Which Five Are Ground Handling Items and Four Are Expendable Launching Parts*

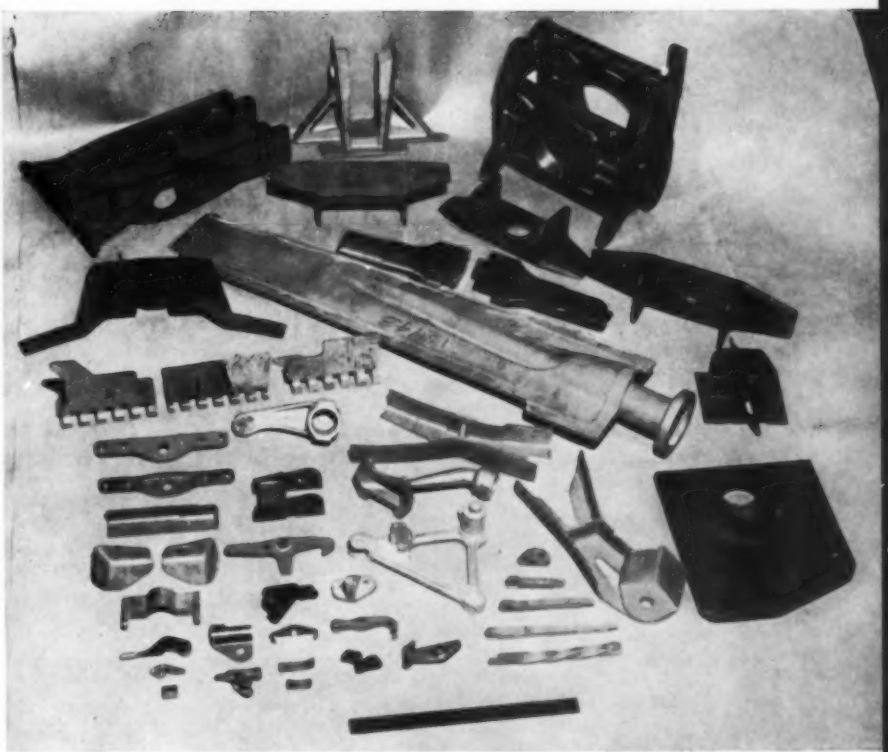
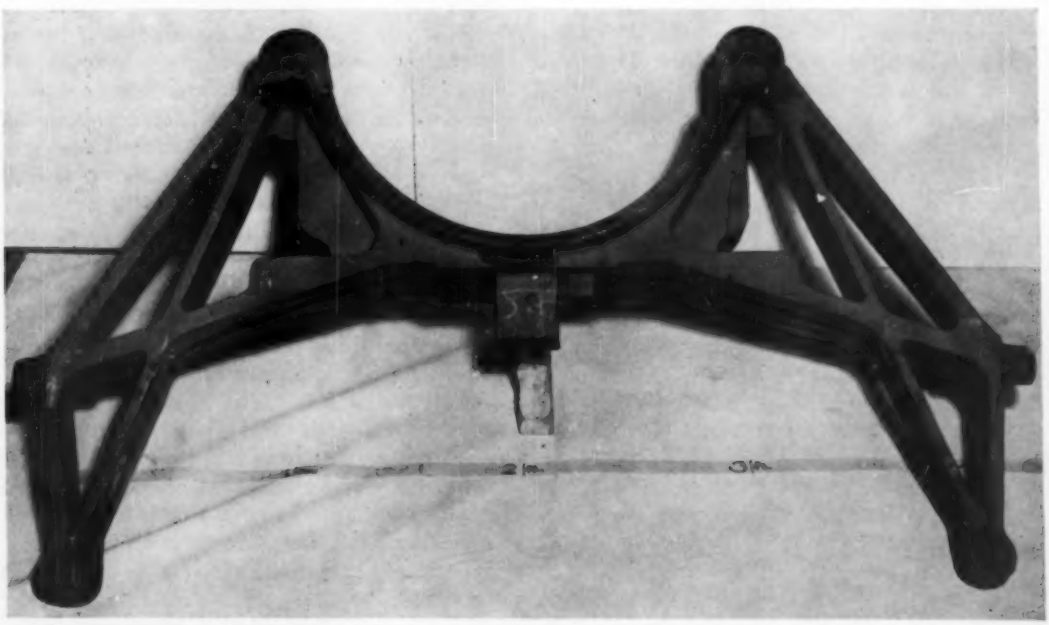


*Fig. 3 – A Selection of Steel Castings for Aircraft Applications Made by the Various Processes*

**Quality** – If we are to achieve our objectives with minimum weight and with no extra casting design factor, we must have sound, clean metal, or at least metal of the quality specified by the drawings. Too little is known of the specific effect of common defects in castings. Some work sponsored by the Steel Founders' Society has proved that the fatigue characteristics of cast steel are the equivalent of wrought steel provided the cast steel is of high quality. In order to assure adequate quality, we specify radiographic quality in selected areas in accordance with load-carrying requirements. We also specify mechanical properties of coupons taken from the castings. Without exception, in order to achieve the most favorable strength-to-weight ratio, airframe castings will be specified in the heat treated condition.

As an aid in simplifying testing required and

*Fig. 4 – Frame Casting for Regulus II of 4340 steel weighs 285 lb.*



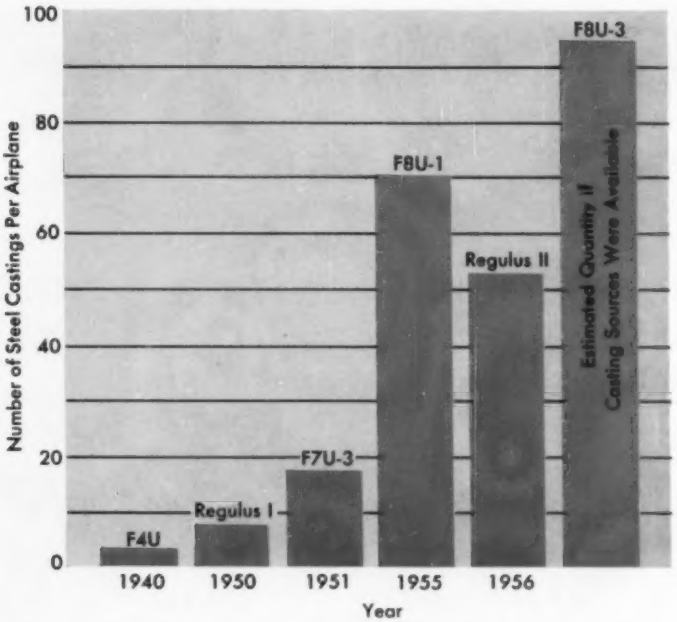



*Fig. 5 – This Chart Shows the Trend in Use of Steel Castings at Chance Vought Aircraft*

minimizing the number of verification procedures, we are launching a program to determine specific effects of gaseous elements in a selected alloy. This alloy will meet a large portion of current airframe requirements with respect to mechanical properties and oxidation and corrosion resistance, and could be used as a standard alloy after sufficient knowledge is compiled. It is the intent to specify content of gaseous elements along with other elements after their specific effects are determined.

**Performance** – This characteristic is determined in several ways. For instance, if the minimum castable thickness for the process employed gives a metal thickness considerably over the load-carrying requirement, aircraft engineers are generally satisfied if the casting is: (*a*) X-ray sound, (*b*) up to minimum dimension, (*c*) properly heat treated, and (*d*) contains no appreciable surface deterioration. If, however, the part is sized to give minimum weight and little or no margin, the aircraft engineer will insist on a static performance test. If the casting is subjected to repetitive loads, a fatigue test will also be required.

**Production Performance** – This characteristic involves several factors, among them being delivery as promised and delivery of every casting as near like those tested as possible – in other words, no changes in foundry practice, pouring temperature, gating or heat treating procedures. Without this assurance, the casting purchaser will be forced to specify repeated tests over and above normal inspection tests, for the effects of some of the possible changes cannot be inspected by ordinary means.

**What Is Required of the Foundry?**

First, the foundry must be adequately equipped. By this, I mean something quite apart from automatic sand handling, flask conveyers, and so on. I mean equipped with a means of rapid chemical analysis, mold material analysis, mechanical and metallurgical testing, accurate temperature control for pouring and melting, mold permeability or, better yet, mold thermal conductivity control, and adequate final inspection. It is desirable that the foundry be equipped for heat treating castings so that responsibility need not be split. It's also desirable that the foundry have available a machine shop. This arrangement would place all the responsibility on the foundry; at the same time, it would permit adaptability in that the casting could be modified for the benefit of the foundry and still produce the desired result by machining certain surfaces. The foundry should have a capable estimator. It is very discouraging to receive a request for an increase of unit price when follow-on orders are placed, since they are usually for greater quantities than initial orders. The foundry should assess its capability to produce and should quote delivery as honestly as possible.

**Target for Aircraft Steel Castings**

1. Minimum machining requirements.
2. Resistance to corrosion, erosion and thermal shock.
3. High strength of the order of 250,000 psi. at high temperatures, such as 1000° F.
4. Retention of strength and other mechanical properties on continued exposure to high temperature.

Figure 5 shows the trend in use of steel castings at Chance Vought Aircraft. Other aircraft, including missiles, will show this same trend just as soon as the airframe manufacturer is convinced that reliable steel castings are available. As the performance of aircraft is extended, steel and superalloys must be employed. The cost of machining parts from steel is from one to four times more than aluminum. It is too early to say definitely just how much more it will cost to machine parts from superalloys. However, a ratio of from 10 to 25 compared with aluminum seems reasonable.

What does this mean? It means simply that the airframe manufacturer must utilize high-integrity, close-tolerance castings to reduce the amount of machining whenever possible. This situation should result in a market for airframe steel castings of at least $250 million yearly.

The advent of superalloys as structural members, coupled with extended usage of titanium, zirconium, beryllium, columbium and molybdenum, will bring about a "new look" in foundry operations. Melting equipment will be radically different with sweeping changes in molding materials and molding practices. We visualize a casting facility of the future as a precision operation – air-conditioned, clinically clean and requiring enormous amounts of electric power.

**Mutual Benefits**

The airframe manufacturer must be convinced that he cannot dictate to the foundry. In other words, he cannot hold to the attitude "just make it like the drawing". He must respect the ability of the foundry engineers and be willing to accept recommended changes. Through such joint efforts, the airframe of the future can be constructed largely of steel or superalloy cast components.

We visualize high-quality, close-tolerance castings, much larger than the steel casting shown in Fig. 6. This casting weighs 32 lb. and was machined only on the flat end surfaces and the bearing race-ways. The cost saving here compared with previous method of manufacture was of the order of $1200 per part and there are two parts per aircraft. Under test, the casting withstood 200% of the minimum structurally required load, and still did not fail. The test was stopped because of jig limitations.

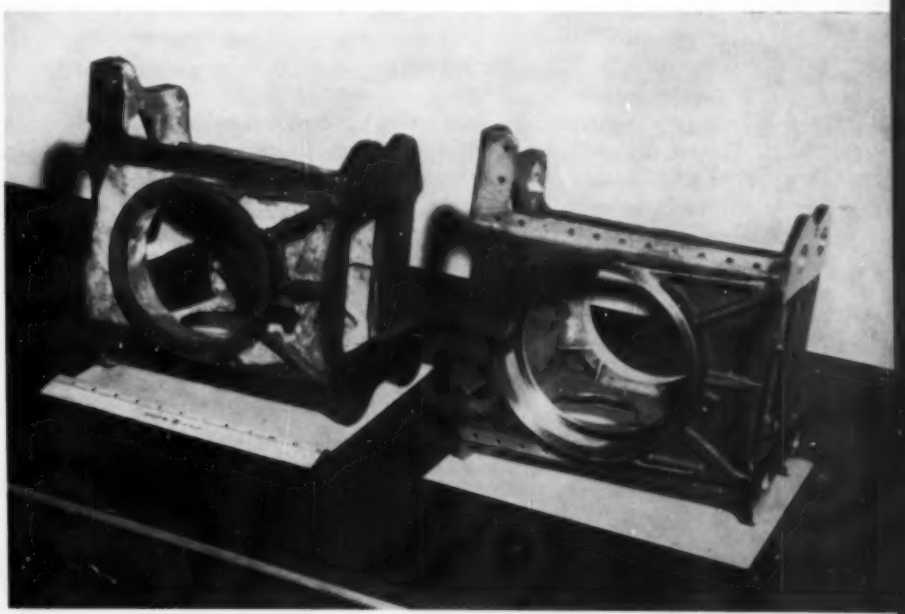


*Fig. 6 – This Casting (Two Are Used Per Aircraft) Saved $1200 Over the Previous Method for Manufacture of This Part. It was machined only on the flat end surfaces and bearing surfaces to give the finished part (right)*

# Introduction to Outer Space*

THERE ARE FOUR principal reasons for undertaking a national space program: The first is the compelling urge of man to explore. Second, if space is to be used for military purposes, we must be prepared to use space to defend ourselves. Third is national prestige. Fourth, to add to our understanding of the universe.

The basic laws governing satellites and space flight are fascinating in their own right. And while they have been well known to scientists ever since Newton, they may still seem a little puzzling and unreal to many of us. Our children, however, will understand them quite well.

**Why Satellites Stay Up** – We all know that the harder you throw a stone the further it will travel before falling to earth. If you could throw a stone at the fantastic speed of 15,000 miles per hour (mph.), it would cross the Atlantic before the earth's gravity pulled it down. Now imagine being able to throw the stone just a little faster, say about 18,000 mph.; the stone would travel so far that it would overshoot the earth, so to speak, and keep falling until it was back where it started. Since in this imaginary example there is no atmospheric resistance to slow the stone down, it would still be travelling at 18,000 mph. when it got back, so around and around it goes. From the stone's point of view, it is continuously falling, except that its very slight downward arc exactly matches the curvature of the earth, and so it stays aloft – or as the scientist would say, "in orbit" – indefinitely.

Neither stones nor satellites can be sent whizzing around the earth at tree-top level. They must first be lifted beyond the reach of atmospheric resistance. There is, however, a slight vestige of atmosphere even a few hundred miles above the earth, and it is this resistance, however slight, that has set limits on the life of all satellites launched to date. The higher the satellite, incidentally, the less speed it needs. T s, the moon's speed is only a little more th 2000 mph., but to launch a satellite toward more distant orbit requires a higher initial speed and greater expenditure of energy.

**The Thrust Into Space** – To place satellites weighing 2000 lb. in orbit requires a thrust in the neighborhood of 400,000 lb. Rocket engines able to supply this have been under development for some time. The engine is divided into two or more stages, which can be dropped one by one in flight, thus reducing the total weight that must be accelerated to the final velocity.

If we want to send up a device that will reach the moon, we need to accelerate the final stage to about 25,000 mph. – the "escape velocity" – very near the beginning of the trip. Thereafter the rocket will be gradually slowed down by the earth's pull, but it will still move fast enough to reach the moon in two or three days.

Sending a small instrument carrier to Mars, although not requiring much more initial propulsion than a simple moon shot, would require eight months time or more, and the problems of navigation and final guidance are formidable.

While the total weight of the rockets has been up to 1000 times that of the satellite, it will be ultimately possible to reduce this to 50 to 100 times the weight in orbit.

**The View From a Satellite**—Much that scientists wish to learn can be gathered by instruments and transmitted back to earth with today's rugged and tiny electronic equipment. Messages from Mars, 100 million miles away, can be transmitted to earth with less power than that used by most commercial broadcasting stations. This leads up to an important point: The cost of transporting men and material through space will be extremely high, but the cost and difficulty of sending *information* through space will be comparatively low.

A satellite in orbit can sample the environment, survey the earth, and view the universe unobstructed by our atmosphere. "Empty" space is rich in energy, radiation, and fast-moving particles of great variety. There are vast systems of magnetic fields and electric currents that are connected somehow with the outward flow of charged material from the sun. The satellites will also give a three-dimensional picture of the earth's gravity and its magnetic field.

The satellite that will turn its attention downward holds great promise for weather forecasting. Weather stations on land and sea now watch only about 10% of the atmosphere. Two or three weather satellites could make a cloud inventory of the whole globe every few hours, from which meteorologists believe they could spot large storms in their early stages and chart their direction with great accuracy.

Satellites could surely – and rather quickly –

*Verbatim extracts from "An Explanatory Statement Prepared by President Eisenhower's Science Advisory Committee", James R. Killian, Jr., Chairman. Those interested in details or other viewpoints may consult the 1375-page "Inquiry Into Satellite and Missile Programs", the record of hearings before the Senate's Committee on Armed Services between Nov. 25, 1957 and Jan. 23, 1958.

be pressed into service for expanding world-wide communications, including intercontinental television. Several suitably equipped and properly spaced satellites would be able to receive TV signals from any point on the globe and to relay them directly – or perhaps via a second satellite – to any other point. Powered with solar batteries, these relay stations in space should be able to keep working for many years.

Other instruments would measure the solar energy coming to and reflected back from the earth. In the long run the earth has to send back into space exactly as much heat energy as it receives from the sun. But there is an excess of income in the tropics and an excess of outgo at the poles. This unbalance is continuously rectified by atmospheric changes we call "weather".

**A Close-Up of the Moon** – What scientists most like to learn from a close-up of the moon is: Was it originally molten? Does it now have a fluid core, similar to the earth's? And just what is the nature of the lunar surface? The answer should shed light, directly or indirectly, on the origin and history of the earth and solar system.

While the moon is believed to be devoid of life, even the simplest and most primitive, this cannot be taken for granted. Some scientists have suggested that small particles with the properties of life – germs or spores – could exist in space and could have drifted on to the moon.

**On to Mars and Venus** – We know quite enough about Mars to suspect some form of life. Both Mars and Venus have atmospheres that can be used to support balloons for meteorological soundings and photographing surface features. The atmosphere of Venus appears to be a dense layer of clouds so that its surface has never been seen.

**Military Applications** – There are important, foreseeable, military uses for space vehicles in communication and reconnaissance.

The use of satellites for radio and television relays has been described, and it does not take much imagination to foresee uses of such techniques in long-range military operations.

The reconnaissance capabilities of a satellite are due to its position high above the earth and to the fact that its orbit carries it in a predictable way over much of the globe. Its disadvantage is its necessarily great distance. To the human eye, a football stadium 200 miles away would be a barely distinguishable speck. A telescopic camera can do a good deal better and it is certainly feasible to obtain reconnaissance information and relay it back to the earth by radio.

Satellite bombers, military bases on the moon and such proposals do not appear achievable at an early date. They also appear to be clumsy ways of doing a job.

Take one example – the satellite as a bomb carrier. A satellite cannot simply drop a bomb. An object released from a satellite doesn't fall. So there is no special advantage in being over the target. The bomb would have to be launched with a rocket comparable in size to an intercontinental missile. Launching from a moving platform has every disadvantage compared to a missile base on the ground.

There may well be important military applications which we cannot now foresee. The history of science and technology reminds us sharply of the limitations of our vision. Our road to future strength is to achieve scientific insight and technical skill; in this setting, our appropriate military strength will grow naturally and surely.

**A Space Timetable** – The following timetable suggests the approximate order in which some of the objectives may be attained. It is not dated, since the scale of the effort is still uncertain:

**Early** – *(a)* Physics; *(b)* geophysics; *(c)* meteorology; *(d)* minimal moon contact; *(e)* experimental communications; *(f)* space physiology.

**Later** – *(a)* Astronomy; *(b)* extensive communications; *(c)* biology; *(d)* scientific lunar investigation; *(e)* minimal planetary contact; *(f)* human flight into orbit.

**Still Later** – *(a)* Lunar exploration with instruments; *(b)* planetary exploration with instruments; *(c)* human lunar exploration and return.

**Much Later** – Human planetary exploration.

In conclusion, we venture two observations: Research in outer space affords new opportunities in science, but it does not diminish the importance of science on earth. It would not be in the national interest to exploit space science at the cost of weakening our efforts in other scientific endeavors.

Our second observation is prompted by technical considerations: Rocketry and other equipment now used in space technology must usually be employed at the very limit of its capacity. This means that failures of equipment and uncertainties of schedule are to be expected. It therefore appears wise to be cautious and modest in our predictions about future space activities – and quietly bold in our execution.

# *Materials for a Space Traveller*

*By RODNEY A. JONES**

**How will constructional materials and instrumentation for space vehicles be affected by very high vacuum, solar radiation, cosmic rays, ionized atoms, meteorite dust, zero gravity? (T24f, 17-57)**

THE LONG "LEAD TIME" required to convert a drawing-board concept into a flying aircraft has been emphasized times without number. It is not so well understood that it takes years before a new material can reach a user in proper quantity and uniformity. Lastly, it is worthy of emphasis that improved aircraft of the foreseeable future depend heavily on improved materials. To see to it that these materials are available in time is one of the chief responsibilities of the Air Research and Development Command of the U.S. Air Force, and it should be obvious that the long view should direct today's activities.

For some years, the needs of "astronautics" have also been under close study. (By "astronautics" is meant flight at speeds, elevations and distances beyond the capabilities of aeronautics, which by definition depend upon the presence of atmospheric air.) This broad program is intended to answer the following questions:

1. What will be the future requirements?
2. Can these be met with existing materials?
3. What avenues of research offer best chance of successful development of advanced materials?

In one short paper it is impossible to do justice to all three of these problems. Since Questions No. 2 and No. 3 depend upon a good idea of Question No. 1, and Question No. 1 brings up some rather novel concepts, the present paper will be confined to its brief consideration.

*Colonel, U.S. Air Force, Staff Officer for Materials Research and Development Programs, Wright Air Development Center, Wright-Patterson Air Force Base, Ohio. From an address before a joint meeting of the Cleveland Chapters, American Society for Metals and American Society for Testing Materials, April 7, 1958. Acknowledgment is made to Lloyd D. Richardson of the Materials Laboratory at Wright Air Development Center as co-author.

## Future Requirements

As a start, one should look at the two parameters, speed and altitude, and plot the limitations of the various types of vehicles. This is attempted in Fig. 1. As will be developed in more detail later and shown in Fig. 2, *current* types of aircraft occupy only the lower left corner – below 13 miles altitude and less than 2000 miles per hr. speed. Super-performance aircraft can doubtless operate at two or three times this speed at higher altitudes where aerodynamic heating is within tolerable limits. There is a limit, however. It will be noted on Fig. 1 that, above 20 to 25 miles, aerodynamic lift increases very little with increasing speed; about 99% of the atmosphere is below this level, and from a practical standpoint this puts a ceiling for aircraft operation. There is also a *lower* limit established by aerodynamic heating of external surfaces to equilibrium temperature. This is shown on Fig. 1 by the 2000° F. curve. The 1000 and 3000° F. limits are also indicated. Between the lines for equilibrium temperatures and the limit for dynamic lift is the "flight corridor". The depth of this corridor – in fact, whether it exists at all – is determined solely by the ability of materials to withstand high temperatures. (The exception might be for short periods of flight, using insulation or a "heat sink" design.) It appears likely that 1000° F. is perhaps a more realistic upper temperature limit for aircraft structural materials, and under these conditions the flight corridor all but disappears!

In view of aerodynamic heating, the problems of operating within a narrow flight corridor, and the great power required to push a vehicle through the atmosphere, it is logical to get above the atmosphere and utilize centrifugal lift for lengthy, long-range operations at high speed. This is the realm of astronautics. When speeds of approximately 17,000 miles per hr. are attained, the satellite will go into orbit and further propulsive power is not needed. If the altitude is high enough, there is little drag or aerodynamic heating. At still higher speeds of about 24,000 miles per hr., the earth's gravitation is overcome and space flight is achieved, but some power will be needed for control, to change course as necessary. Heat resistant materials are needed in satellites and space vehicles which must return to the earth. A free-falling vehicle reaches the dense air levels at very high speeds and is subjected to extreme frictional heat. If it can be slowed down at high altitudes by reverse thrust engines or by drag devices, this aerodynamic heating is less severe. If a man-carrying vehicle is to return and land at a designated point on the earth, it must probably have some type of a wing. Such a vehicle may dip down into the atmosphere until it reaches a maximum allowable temperature, then skip back up to cool off by radiation. After a few such skips, it is slowed enough to come down the "flight corridor" and land as a conventional aircraft.

Propulsion systems for both aeronautics and astronautics are indicated in Fig. 2. Here again aerodynamic heating limits operational speeds at lower altitudes. Air-breathing engines can, of course, operate only within the sensible atmosphere, and the available and foreseeable materials of construction will require a certain amount of cooling from the airstream. Even though the top temperature limit in the "hot" end of the engine – and its thrust – is essentially fixed by the capabilities of heat resistant materials, air-breathing engines will continue as important propulsive devices for aircraft. The significant point is the dominance of rocket engines for astronautics. Their fuel may be either solid or liquid chemicals or nuclear energy. Eventually, in order to obtain the fantastic speeds required for space travel, ion and photon rockets may provide the power!

From this brief discussion, it can be concluded that astronautics will not lessen the pressing requirements for materials. Perhaps the emphasis on flights of long duration within the atmosphere, where aerodynamic heating is severe, will be decreased somewhat, but the requirements for materials of improved heat resistance and strength remain as urgent as ever. There is no indication that the earth's atmosphere will disappear, and it must be penetrated at least twice in every trip to and from outer space! Furthermore, there is no indication that propulsion systems not involving high temperatures are in the offing.

The present aeronautical requirements for materials with higher strength-to-weight ratios will be even more urgent for astronautics. The power or thrust needed to put an ounce of surplus weight into space is fantastic; from a cost standpoint alone it must be eliminated. For example, the structural weight of a long-range ballistic missile goes up 30 lb. for every additional pound of useful load. Another rule-of-thumb is that it takes 1000 lb. of additional take-off weight (fuel and structure) for each additional pound of satellite for an orbit of 300 miles alti-

tude.* Under such circumstances, practically no lighter weight material which will do the job can be eliminated from consideration on the basis of cost alone. If it can be obtained or developed, it must be used!

Weight reduction – already of prime importance in aeronautics – will be so important in astronautics that it deserves further consideration at this point. Metals or mill products are produced commercially to specification limits – as for example tensile yield within a given range, or a specified thickness plus or minus a certain tolerance, and so on. The design is then made for the lower limit of specified strength and for the thinnest sheet which meets the specification. This results in excess structural weight – excess weight which now must be pared to the bone. I wish to emphasize that this paring can best be done through closer quality and dimensional control, *plus* more complete and refined materials evaluation. Much of the testing will have to be of the nondestructive type on the actual material in the part. Trends in this direction are not new to the aircraft industry and its suppliers. They will have to be extended to meet the demands of the future.

### Natural and Induced Environments

A consideration of the requirements for astronautic materials quickly brings one to a study of the natural and induced environments which are unique to space or are important to space operation and all that it implies. These will now be briefly considered one by one.

**Very High Vacuum** – High vacuum probably typifies space more than any other single environmental factor. At 100 miles altitude the gas density is so low that the mean free path of the molecules is in the order of 100 ft., and a pressure corresponding to this altitude is necessary for testing of equipment and materials. Vacuum is not expected to have significant *direct* effects on most materials; however, the indirect effects plus other environmental factors may be very important. Examples are the vaporization of liquids, removal of plasticizers from plastics and sublimation of materials of high vapor pressure. Vibrations will not be dampened; leakage through seals will be aggravated; heat convection will be nil; there will be no adsorbed air layer to lubricate and prevent galling of rubbing metals; corona discharge, arc-over or surface ionization will affect insulation. On the other hand, oxidation and corrosion should be much reduced if not entirely eliminated; hence, materials heretofore unacceptable because susceptible to oxidation or corrosion may provide needed capabilities.

**Solar Radiation** – The degradation of organic materials by the sun's radiation is familiar to us as the weathering of plastics and paints, the weakening of fabrics, and the discoloration of glass. Materials in space will be exposed to its full intensity, hence the effects may be greater, especially in the ultraviolet region, about which little is known, since most of these wave lengths are absorbed by the atmosphere.

**Ozone** forms by ultraviolet energy (in preference to molecular dissociation into atomic oxygen) between 15 and 25 miles; however, it may exist over much wider ranges. Ozone is very reactive with many organic materials, such as rubbers. It is fairly stable and may persist in harmful concentrations in the "air" drawn into vehicles operating in the 20-mile region. Since it is harmful to humans, ways of decomposing or removing it may have to be found. In any event, it should not present a serious problem for vehicles which spend only a little time in the "ozone layer".

**Dissociated and Ionized Gases** – At altitudes above about 50 miles, oxygen begins to be dissociated into the atomic form by the sun's energy. Above 75 miles, the oxygen is nearly 100% atomic and highly reactive. A similar situation occurs with nitrogen at slightly higher altitudes, although atomic nitrogen is comparatively inert. At various levels above 45 miles, an appreciable percentage of the existing gas is also ionized. It is thought that the effects of ionized gases will be chiefly electrical.

**Auroras and Cosmic Rays** – Auroras consist of arcs, glows, coronas, rays and flames caused by ionizing radiations penetrating the atmosphere at altitudes above 50 miles. The maximum height of the auroras is probably not above 200 miles, and they are of greatest intensity in polar latitudes. An orbiting satellite would thus be exposed to their effects for only a small proportion of the time, if at all. Above the auroral region, space vehicles will be bombarded by primary electrons, and when these strike the metallic skin, X-rays are formed and these will penetrate the skin. No direct effect on materials would be expected, but material selection may be influenced by the need for protecting indi-

*"Introduction to Outer Space", the memorandum from President Eisenhower's Science Advisory Committee, says this ratio may eventually be reduced from 1000 to 1 to 50 or 100 to 1.

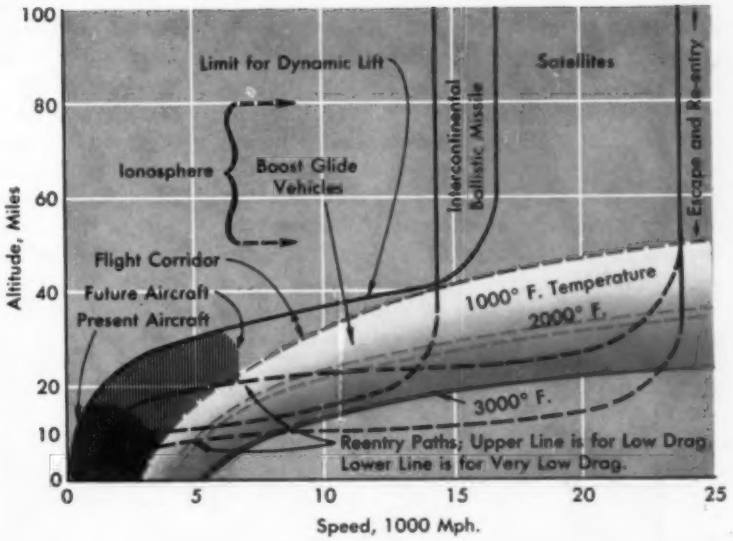



*Fig. 1 – Operational Limitations of Various Types of Vehicles as Related to Altitude and Speed*

viduals or equipment. This latter remark may also apply to cosmic rays, although over long periods of exposure some damage to materials by radiation is possible.

**Meteoric Particles** – A significant number of particles of dust size will be encountered capable of sputtering and eroding the surface. Optical surfaces and Geiger windows may have to be protected when not in use. For long exposures, the effects may actually impair the integrity of the material. The experiments now under way during the International Geophysical Year should provide considerable information on this subject. The number of meteoric particles decreases sharply with increases in size and the probability is small that a vehicle will be hit by a piece large enough to penetrate its skin – except when we are able to put up large, permanent satellites and space stations.

**Temperatures** – Probably no induced environmental factor has received more attention in recent years. Heat resistance has come to be one of the controlling properties in material selection for both power plant and airframe construction. As a result, much of the research and development effort in aeronautics has been pointed in this direction. The question now arises as to whether this factor will continue to have dominant importance in astronautics. As mentioned previously, there are no indications that the requirements for better high-temperature materials for power plant will be decreased. Likewise, the problems of aerodynamic heating will remain severe as long as one portion of the flight leaves or enters the atmosphere of the earth or another planet. But what about the temperature of a vehicle in space?

The equilibrium temperature of an exposed surface depends upon a balance between the heat that it absorbs and the heat that it radiates. Physicists have given us an equation which says that this temperature varies as the fourth root of the ratio between the coefficients of absorptivity and emissivity. If not absorbing any heat from the sun, it would cool by radiation to a few degrees above absolute zero. Fortunately, it is relatively easy to regulate surface absorptivity and emissivity by selecting the right material or treating its surface in order to maintain moderate temperatures in space. For example, our satellites were designed to have internal temperatures in the range of $-40$ to $+177°$ F. Preliminary indications from "Explorer I" are that habitable internal temperatures do exist; thus the design parameters are apparently being verified. How much the temperatures will change due to surface abrasion by meteoric dust remains to be determined. Internally generated heat from power plants and electronic equipment will also influence the heat balance. Likewise, the percentage of orbit time exposed to solar radiation will affect the temperature and whether or not the satellite is spinning will affect its distribution.

**Zero gravity**, which will exist in an orbiting satellite, cannot be simulated at the present time except for short periods as in an aircraft flying in a tight vertical circle. (Freely falling bodies

also develop near-zero gravity conditions for short times.) While many of its effects are interesting and unusual, no significant direct effects on materials are anticipated. However, some of the indirect effects may be important. Convection due to temperature differentials in liquids and gases will not occur; cooling of hot spots and distribution of heat will be by radiation and conduction exclusively, and forced cooling may be necessary. This will result in local hot spots and steep temperature gradients especially on bearings. If the vehicle is rotated to induce gravity effects – as the spinning dumbbell shape dear to science fiction authors – the centrifugal loads will be high. In fact, centrifugal loads plus the forces from internal pressurization will constitute the primary stresses acting on a satellite.

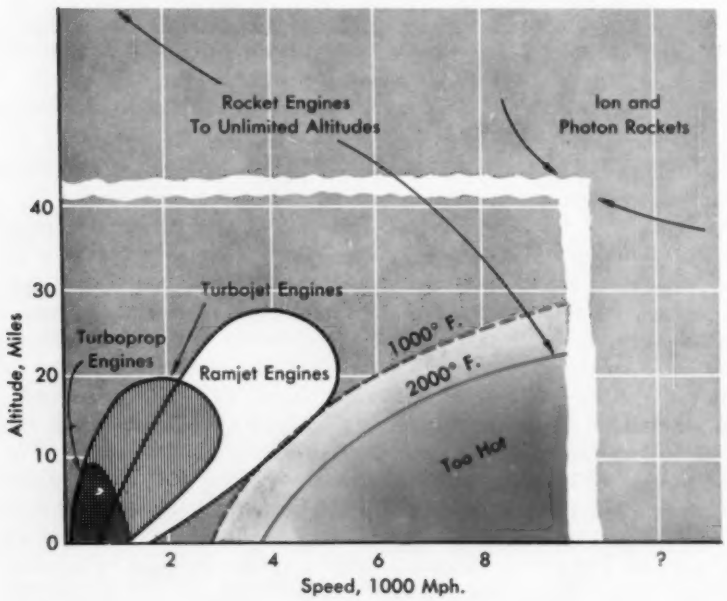



*Fig. 2 – Limitations of Various Systems of Propulsion as Related to Altitude and Speed*

### Summary of Anticipated Effects

After this consideration of the various space environments, the conclusion is reached that they will certainly complicate the future requirements for materials, but no new bottlenecks or insurmountable problems are foreseen. The bill of materials for satellites, space ships and re-entry vehicles will undoubtedly be more varied than for customary aircraft. Each component and structural part must be made of the material which is best suited functionally for the job, and there will be many unique or special jobs to be done. This does not exclude the use of "old hat" materials such as aluminum, magnesium, steels and conventional high-temperature alloys. These will always be good materials; they have the advantage of a background of manufacturing knowledge and wide experience in diverse uses. They are very adaptable and they will constitute a large fraction of the structural weight of astronautical vehicles. Perhaps the high-strength reinforced plastics will also be found in the internal structures, although their durability in simulated space environments in not now known.

The special-purpose materials are apt to cause most of the headaches. Substances which will withstand the extremely high temperatures of propulsion systems and re-entry vehicles are already receiving much attention in a comprehensive research and development program. Various electrical and electronic applications should also continue to receive increased attention; there appears to be no end to the problems faced by the electronics industry. Weight reduction will require the ultimate in strengths of materials and may also dictate the development and use of multifunctional materials – for example, a satellite skin, which, in addition to providing the structural envelope, protects against meteoric particles, regulates internal temperatures, and also converts solar radiation into electrical energy!

# *Getting the Most From a Drying System*

*By JAMES E. GREEVER**

**Very low dew points (−95° F.) are required for manufacture of transistor metals, annealing stainless, and sintering many powder compacts. Even a well-designed drying system will fail to produce such gas unless the purging gas used while regenerating the activated alumina silica gel is equally dry. (J2k, W28q)**

"BONE DRY GAS" is a term often found in the metallurgical literature relating to heat treatment in controlled atmosphere, and presumably it is often used around the shop as a qualitative description of an atmosphere which must have a minimum of water vapor and no undesirable reaction with the work in process. Quantitatively it may be regarded as gas with dew point of −40° F. Many such "commercially dry" gases – nitrogen, hydrogen, helium – are readily available in cylinders, and such gas is ordinarily used "as is". However, irritating troubles have more than once been traced to moisture in such gas. The present writer determined the dew points on 100 cylinders of commercially dry gas at random and got results ranging from +10° F. to −80° F. This range was undoubtedly due to contaminated cylinders and not to the gas directly, but to the user who is interested in getting uniformly dry gas, this fact makes little difference.

Numerous papers presented at recent meetings of the Industrial Heating Equipment Assoc., as published in *Metal Progress*, indicate that atmospheres prepared by partial combustion of natural gas and dried by passing over brine coils (dew point of +10° F. more or less) are suitable for many heating operations on engineering and alloy steels. However, these furnace experts speak of it as good practice – especially when bright annealing – to dry such gas much further. A gas with −40° F. dew point is reported to be *safe* for most operations on steel, because it will permit a normal amount of air infiltration and the production of moisture by reduction of oxides on the work. As a matter of fact, many heat treaters who put "bone dry" gas (−40° F. dew point) into their furnace would probably be surprised to find that the gas actually in contact with the hot work frequently has a dew point of zero to +10° F.

Even inlet gas at −40° F. is not sufficient for completely neutral hardening of high-carbon razor blade strip, which needs gas of −60° F. dew point *on the stock*. Likewise, any larger content of moisture will spoil a bright annealing operation on high-chromium steels such as stainless. The ratio of $H_2O$ to $H_2$ in the atmosphere gas for the heating of such metals as beryllium, silicon and germanium must be *very* low. The moisture problem is also frequently acute in the sintering of powder metal compacts, where the ratio of total surface to total mass of metal is quite high.

Now how can a large user secure proper quantities of dry gas, gas in the range of −90° F., as is necessary in the special atmospheres used in the production of semiconductor metals, transistors and similar electronic devices? He can either buy them or he can dry them for himself. Not too surprisingly it often hinges on economics.

**Commercial Sources** – Extremely dry nitrogen, as low as −100° F. dew point, is now readily available from many of the larger gas manufacturers. In fact, General Electric's Electronic Components Div. has purchased it on special order from Linde Air Products Co. in cylinder form. However, our capacity is such now that we obtain such dew points from a supply of liquid nitrogen located near the point of maximum consumption. The reader may be assured

*Metals Engineering, Semiconductor Products Department, General Electric Co., Syracuse, N.Y.

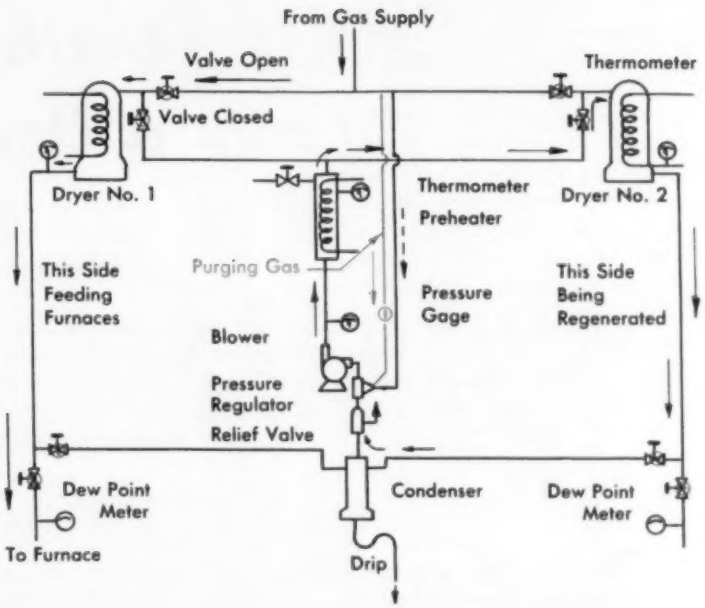



*Fig. 1 – Piping and Equipment Diagram Showing Usual Method for Regenerating Driers Using Purging Gas From Main Supply. To switch driers all valves shown in red would be reversed*

that with little or no effort he may purchase such dry nitrogen, but of course will have to pay a premium. This premium price is not out of line if the user actually requires gas of this dryness in moderate quantities.

The situation changes if large amounts of gas are consumed. The capital, maintenance and operating charges of an efficient drying system may then easily be less, per cubic foot of gas at the furnace inlet, than the premium quoted by the gas manufacturer. Recirculating and purification systems are also demanded when expensive gases such as helium are being used.

The operations at Semiconductor Products Dept. of General Electric Co. are an example. At the Syracuse plant semiconductor devices of various types are manufactured and superpurity germanium and silicon prepared for use in these devices. Extreme purity of the gas atmosphere involved in the production operations is manda-

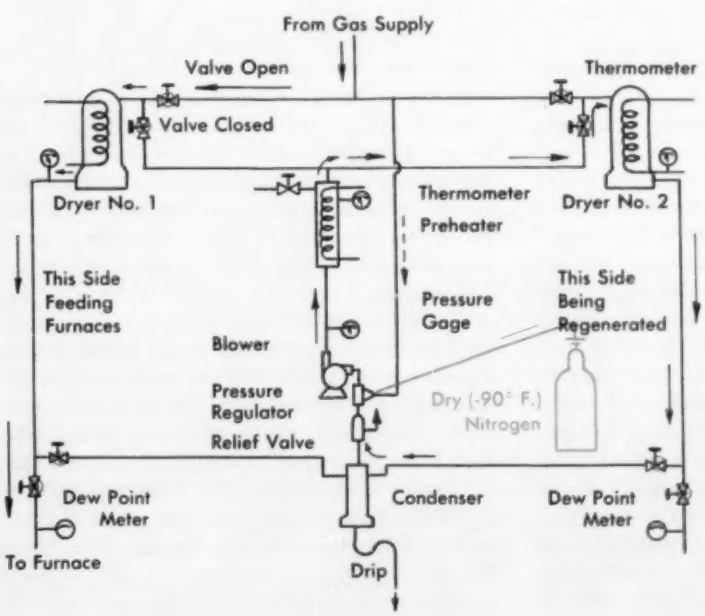



*Fig. 2 – Suggested Method for Improving Performance by Using Dry Nitrogen (—90° F. Dew Point) From an Auxiliary Tank as the Purging Gas*

tory. We also found that numerous commercial driers usually yield gas with a dew point of −60 to −70° F. (We would like −90° F. or lower.) In very humid weather or when the gas being fed into the system is unduly moist, a furnace atmosphere with a dew point of only −40° F. is not unlikely even though all equipment is properly sized for the job it must do.

**Drier Operation** – Probably here is a good place to pause and explain a drier for the benefit of those who have not operated one. Without entering into the constructional details, it may be said that it is simply a vertical tank filled with an efficient dessicant – usually activated alumina or silica gel. It has an auxiliary heater, either a resistance coil within the tank, or a Nichrome ribbon wound around its outside. The purpose is to heat the dessicant to 350 to 500° F. which vaporizes any absorbed water, and this moisture is carried out of the tank by a slow stream of the dry atmosphere from a cylinder or bled from the main circuit. The temperature of the effluent usually remains under 212° F. until all but the residual water content (5% in silica gel) has been removed. Following this, the temperature of the effluent gas will go up, whereupon the current to the heating element may be turned off. The slow purging stream of gas should be continued until its temperature is below 100° F. All valves are closed and the drier is ready to be hooked into the line.

The above is called the regenerating-heating cycle, and driers so conditioned will remove moisture down to a dew point of −90° F. if filled with silica gel and to −95° F. if filled with activated alumina. It should be obvious that for this maximum efficiency the purging atmosphere should have a dew point of −95° F. to prevent the alumina or gel from picking up any moisture during the cooling cycle.

When the drier is hooked into the line between gas supply and furnace, the moist gases will go through, let's say, from top to bottom. The alumina or silica gel becomes moist progressively as its adsorbing ability is saturated. One might say that the wetness of the drier progresses from the inlet to effluent as the wet gas is passed through; and as long as any adsorbent is left in its original state it will still dry the gas. Once the wet phase works itself to the bottom of the column the dew point of the process gas will rise immediately above −100° F., and this will be shown by readings on the dew-point meter.

An adequately designed drier would be capable of operating at the desired dew point for a minimum of 8 hr., and if its capacity is greater than the usage, it will continue to operate many additional hours. It should be realized that dew point readings will remain steady during that time, but as soon as the wet phase breaks through the adsorbent the dew point will rise sharply. Before this would occur in ordinary production a second or standby tower would switch in, and the nearly exhausted one be reconditioned by the regenerating-heating cycle outlined above.

Figure 1 shows the usual hook-up for two driers where one will supply the needs for 8 hr. while the other is being regenerated, then the roles are switched. It uses the process gas (from the main supply, before drying) for purging the drier during the heating and cooling cycle while it is being regenerated (unit at right of Fig. 1). As the heat is applied by the resistance coil, there is a proportional increase in pressure in this closed system and this is released through the relief valve. The pressure in this entire closed system, upon cooling after the heating period, drops proportionally with temperature, but is raised gradually by feeding process gas in via the pressure regulator. This is usually the same gas that is being fed to drier No. 1. Furthermore, the atmosphere of the closed system undergoing regeneration cannot hope to be drier than the condensation point in the condenser. This is controlled to a large degree by the cooling water temperature and the efficiency of the condenser. If this fairly wet atmosphere is not removed from drier No. 2 prior to cooling, the moisture it contains will be gathered into the adsorbent as it is pumped around in the closed system.

These undesirable factors can be readily eliminated by installing a line to the system from a source of really dry nitrogen as shown in Fig. 2. The entire operations of regenerating the drier can be carried on as previously described, except for one additional point which should be mentioned. It would be well to purge the system thoroughly with the dry nitrogen just prior to the start of the cooling cycle. Then as the pressure is reduced upon cooling, additional dry gas will be drawn from the auxiliary source and thus a dry atmosphere around the adsorbent will be maintained at all times.

Nitrogen was selected as the "dry" atmosphere because it is inexpensive and readily obtainable. It does, however, increase the cost of the process gas to a slight degree but not in any proportion to value received from the −90° F. dew point when this range of moisture impurity is required for a specific process.

# A Prominent American

**William Alvin Mudge**
***Special Representative on Educational Programs***
***The International Nickel Co., Inc.***

# *Metallurgist . . .*

WILLIAM ALVIN MUDGE, one of International Nickel Co.'s metallurgical scholars, worked out the temperature-time factors that allow the nickel-copper-aluminum alloy trademarked "K" Monel to age harden. Affable, he likes to say that he accomplished this by what popularizers of science call a "lucky accident".

Slight, dapper "Bill" Mudge was born in Schenectady, N.Y., Nov. 18, 1892. He went to Union College in Schenectady (B.S., 1914), to Columbia University (M.A., 1915), became professor of chemistry at small Albright College in Myerstown, Pa. (1915-1917), married Helen Gertrude Gates (Mount Holyoke, class of 1913), served in World War I.

Captain Mudge returned to Columbia to earn his Ph.D. under the late, great William Campbell. Another early influence was General Electric's Willis R. Whitney, who gave Bill Mudge summer jobs while at college doing chores around his laboratory. More precious than the pay was the zeal he developed for applied science.

In the early 1920's International Nickel was in an industrial slump. The metal became an industrial alloy in the 1890's in bicycle chain and battleship armor. Now World War I was done, armaments in abeyance, industry in depression. New uses must be found. President Stanley, who had discovered how to make Monel metal, told John Thompson (now chairman of the board) to accumulate a big, energetic research staff. Dr. Thompson turned to Professor Campbell for help, and he recommended Mudge.

New man Mudge's assignment resulted in the hydrogen-ion control of the electrodeposition of nickel and its commercial application in the Canadian refinery at Port Colborne. By 1922 he had turned to study the effect of aluminum on the nickel-copper system — a natural combination in the Canadian ores. In this work he had the good fortune to be directed by Master-Metallurgist Paul D. Merica, who had joined Inco a year earlier from the National Bureau of Standards, as Thompson's first choice in fulfilling Stanley's program.

In 1924 Mudge found under his microscope a eutectic structure (similar to that in oxidized copper) in an unusually hard specimen. He thought he had something new — evidence that the alloy was not the solid solution it was believed to be. He quenched a duplicate sample from 1600° F., and reheated it at 1100° F. overnight. From Brinell 150 the specimen hardened to Brinell 275! But he could find no eutectic structure. Looking at his first specimen again he found his "eutectic" to be particles of dust dried from his etching solution! The important fact remained, however: Certain nickel alloys could be substantially hardened by heat treatment.

Bill Mudge is unusually bookish for a metallurgist. He has been abstracting metallurgical literature, particularly publications, for *Chemical Abstracts* since 1921. He believes that he is the only person "outside perhaps the editorial staff" who has read every issue of *Metal Progress* and *Transactions* from cover to cover.

His literature searches led him to an ironic discovery about age hardening, perhaps anticipating Wilm's work with duralumin and his own work on Ni-Cu-Al by about 20 years. In 1886 in England and in Germany a Swiss watchmaker named Charles Auguste Paillard got patents for nonmagnetizing, nonoxidizing palladium alloys containing 1.5 to 5% nickel for balance wheels and hair springs, claiming that "all the alloys possess the property of acquiring hardness and elasticity by the process used in hardening cymbals and gongs, that is to say, heating to a dull red heat, and then cooling slowly".

With International Nickel, Dr. Mudge progressed from research metallurgist (1920 to 1922) to director of technical services (1947 to 1956). Along the way he published some 50 technical papers, had about 25 patents taken out in his name, joined nine professional societies, lectured on nickel and its alloys. He served (1938 to 1953) as lieutenant commander in the U. S. Naval Reserve. His recreations are fishing, golf, bridge, music, scouting — his proudest honor is from the Boy Scouts of America, whom he had fostered for 30 years.

In 1946 International Nickel began in a small way to utilize his educational experience by having him arrange some small grants to Canadian, U.S. and British higher schools. Satisfied, ten years later the company expanded its allotments to $4,500,000 for the following five years, and appointed as full-time Special Representative on Educational Programs, Office of the President, the International Nickel Co. of Canada, Ltd., and the International Nickel Co., Inc., scholarly, meticulous Metallurgist William Alvin Mudge.

MYRON WEISS

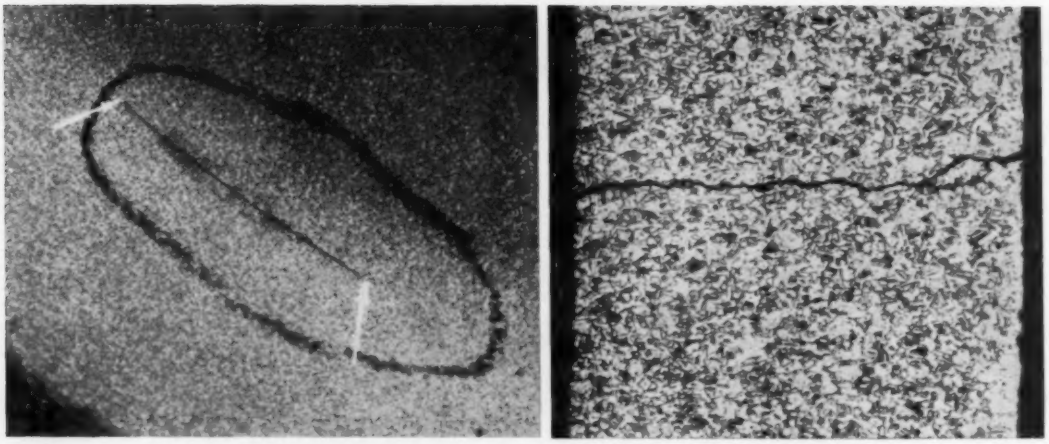


*Fig. 1 – Typical Fatigue Fracture in Hydraulic Tubing. Left, inside diameter, 10 ×; right, cross section, 100 ×*

# *How to Make Hydraulic Tubing Last Longer*

*By C. S. YEN and J. L. WAISMAN**

**Roughness of the tube surface, amount of flattening in a bend, and tensile strength are controlling factors. Careful attention to these variables is necessary if the tube system is to endure the changing stresses caused by pressure pulses.**

THE DESIGNER of machinery with moving parts (shafts, gears, linkages, and the like) must always consider failure in fatigue as a potential hazard. Corners must be rounded, surfaces must be smoothened, materials must be of the proper structure, inclusions must be minimized – all to increase fatigue life of moving parts. Yet, how many designers and production men realize that systems which apparently have no moving parts can also fail in fatigue? Strange, but true.

Consider high-pressure hydraulic tubing systems such as those used to actuate controls in airplanes. No moving parts – and yet, fatigue failures limit the service life (Fig. 1). One of the chronic troubles of such systems is the development of pinhole leaks. These have been identified as tiny fatigue cracks produced by internal pressure fluctuations typical of those indicated in Fig. 2. Therefore, movement of tubing material due to pressure changes, though small, is actually present. The failures resulting from such fluctuations almost always occur in a formed location. An analysis of the shape of the tube in this zone reveals "flattening" of the originally round cross section; this unfortunately accompanies even a well-controlled forming operation. Figure 3 illustrates the flattened tube section and its "breathing" action. High circumferential tensile stresses occur at two locations in the bend; the inside surface at the neutral axis (B) and the outside surface at C. Cracks usually start at the highest stress location.

To investigate this phenomenon (with the idea of increasing service life and producing hydraulic

*Research Metallurgist and Asst. Chief Metallurgist, respectively, Douglas Aircraft Co. Inc., Santa Monica, Calif.

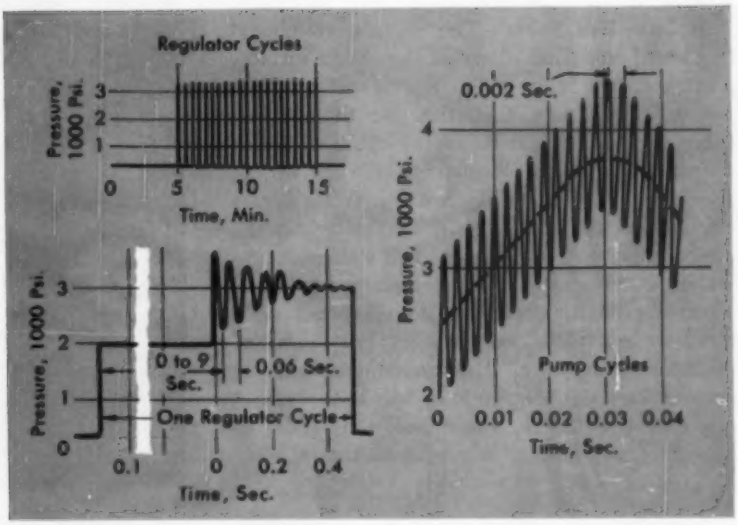



*Fig. 2 – Pressure Fluctuations in High-Pressure Pump Lines. Top left, gross momentary surges; lower left, fluctuations in each regulator cycle; right, detail in fluctuations*

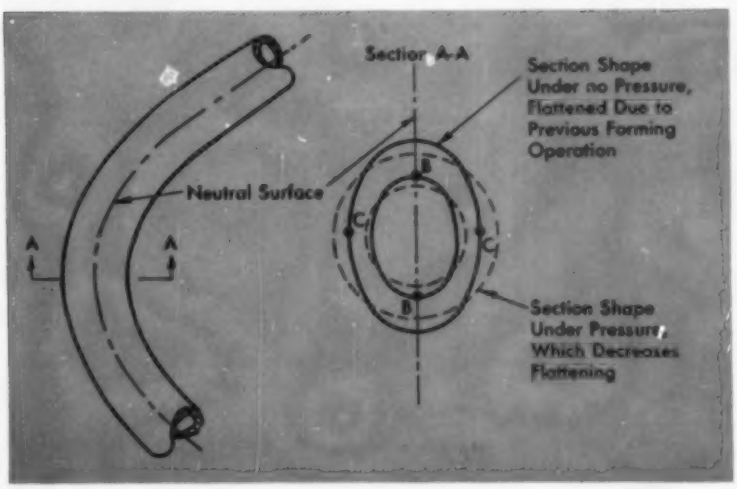



*Fig. 3 – High-Tension Locations Due to "Breathing" of Flattened Section. The points marked B on the inside diameter are the points of highest stress*

systems with thinner tubes or lighter weight), the Air Force initiated research work to determine the effect of various factors influencing failure. Specimen tubes, made of Type 18-8 stainless steel and cold worked according to MIL-T-6845 specifications, were formed as illustrated by Fig. 4. Flattening was limited (by use of close fitting solid or flexible mandrels, careful placement of the mandrel and close control over tube tolerances) to 5% of the cross section where

$$\% \text{ flattening} = \frac{\text{max. diam.} - \text{min. diam.}}{\text{max. diam.}} \times 100$$

All samples were tested in a special pulsing device which could produce pressure pulses from 0 to 10,000 psi. at 1800 cycles per min.

Test results comparing the fatigue strength of straight and formed samples (Fig. 5) proved that, as expected, the formed samples had a much shorter fatigue life than straight samples. Failure locations were at the B and C locations of Fig. 3, most failures occurring at B, though an occasional one began at the indicated outside location. The failures were generally pinhole leaks which became apparent only under fluid pressure. That flattening in the formed portion was the principal factor causing failure in the observed locations was also convincingly demonstrated by Fig. 6. Straight tubes were flattened 5%; this corresponded with the inherent flattening in the bends of the formed tubes. When the tubes were tested, a drop in fatigue strength occurred in the straight tubes similar to the drop produced in the formed portion of the bent tubes; fatigue life also decreased pro-

gressively as the amount of flattening increased.

**Surface Roughness** – The surface roughness of the tubing, particularly at the inside surface, also affects the fatigue life. Rough surfaces have lower fatigue lives than the smooth surfaces; tubes with deep, sharp seams (or intergranular corrosion) have the lowest fatigue life of all. (See Fig. 8.) Obviously, in a rough surface, a stress concentration effect (similar to any notch effect in fatigue) is present. The stress concentration is a function of the relative depth and sharpness of the notch. The sharpness of a notch is generally expressed by the radius of curvature at its base. However, the notches or seams inherent in the rough surface in the tubing are very irregular in shape and the radius of curvature is very difficult to measure. There-

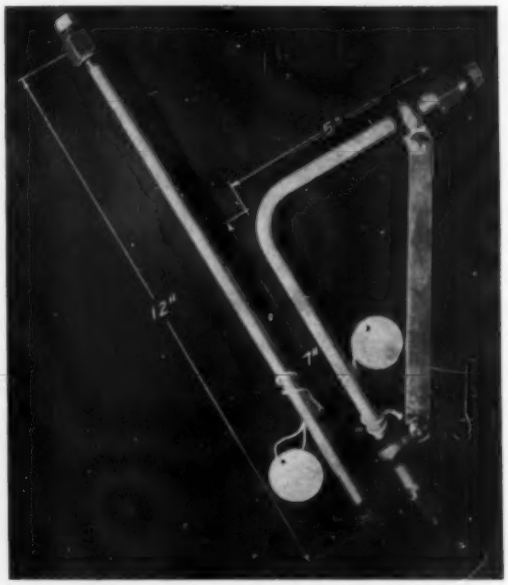



*Fig. 4 – Straight and Formed Tube Specimens Used in the Tests*

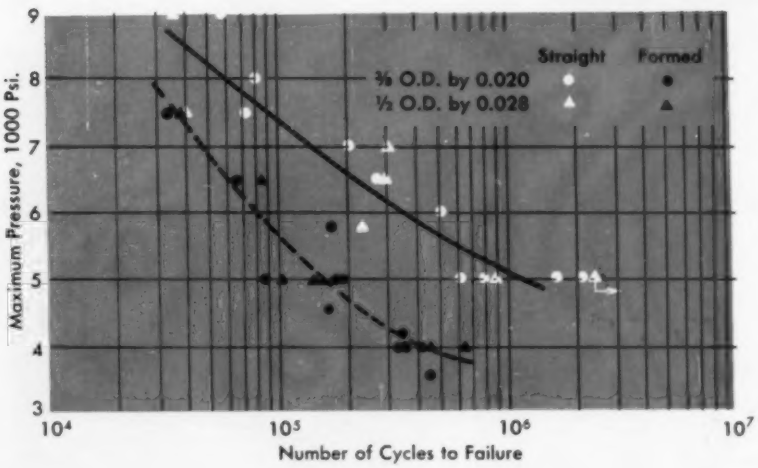



*Fig. 5 – Fatigue Life of Straight and Formed Tubes. Pressure fluctuations varied between the indicated values and 600 psi.*

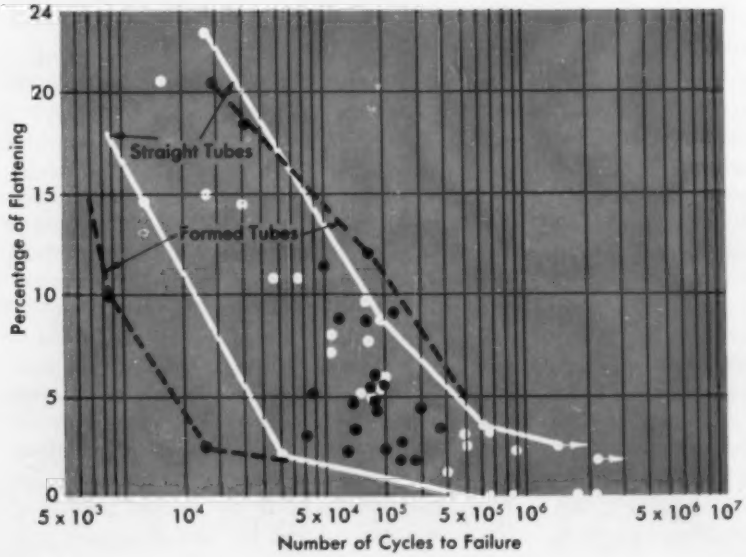



*Fig. 6 – Effect of Flattening on Fatigue Life of Straight Tubes (White Line) and Formed Tubes (Black Lines). The pressure varied between 600 and 5000 psi.*

fore, the "included-angle" at the notch bottom was used as an index of sharpness. Test results proved that the fatigue life rose as this angle became more obtuse. Correlation between depth, sharpness and fatigue is shown in Fig. 8.

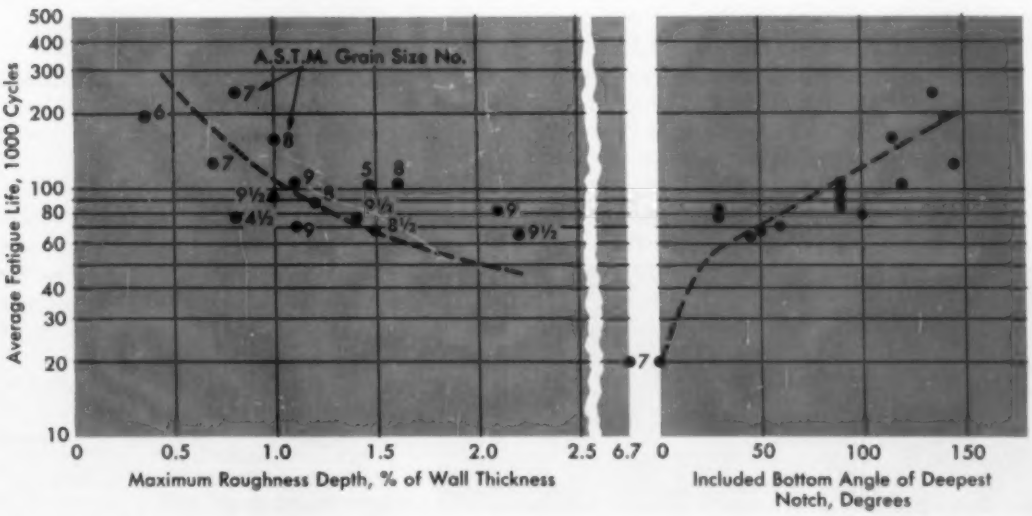
Unfortunately, the depth and sharpness of shallow flaws cannot be determined nondestructively as yet. The usual profilometer surface roughness readings show no correlation with fatigue strength. This is not unexpected since the fatigue strength will be determined by the depth and sharpness of the *worst* flaw, rather than any average flaw. To date, the only effective (but admittedly laborious) inspection method has been a statistical sampling of each lot, a careful visual check of inside and outside surfaces, and a microscopic examination to determine depth and included angle of the flaw.

| Type | Circumferential Profile of Tube Internal Surface (Copied from photomicrograph at 500 ×) Arrows indicate maximum roughness depth and the included bottom angle at maximum depth. Scale: 0 0.001 0.002 0.003 in. | Average Fatigue Life of Formed Tubes. | Average Profilometer Reading at I. D., Micro-inches | |
|---|---|---|---|---|
| | | | Longitudinal | Circumferential |
| Seamless | | 245 kc. | 40 | 45 |
| Welded and redrawn | | 195 | 50 | 63 |
| | | 126 | 50 | 50 |
| Seamless | | 103 | 75 | 75 |
| Seamless | | 82 | 58 | 65 |
| Seamless | | 65 | 40 | 52 |
| Seamless | | 20 | 70 | 75 |

*Fatigue maximum stress is 40% of tube tensile strength; the ratio of minimum stress to maximum is 0.12.

*Fig. 7 – Effect of Internal Surface Roughness on Fatigue Life*

*Fig. 8 – (Left) Effect of Roughness Depth on Fatigue Life. (Right) Effect of notch sharpness (for rough surface) on fatigue life. (Tubes repeatedly stressed as noted in Fig. 6)*



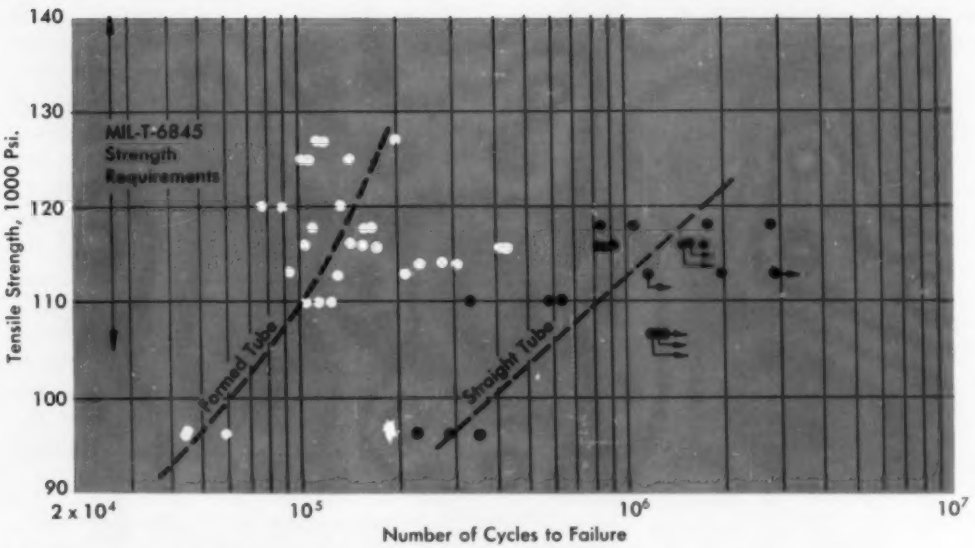



*Fig. 9 – Effect of Tensile Strength on Fatigue Life*

**Tensile Strength** – The third factor which influences fatigue life is the tensile strength of tubing. Some tubes were intentionally made with strengths lower than the MIL-T-6845 requirements; fatigue tests showed that the higher-strength tubes had longer fatigue lives than the lower-strength tubes (Fig. 9). Scatter in this trend was caused by other variables, mostly surface roughness.

The investigation also revealed several factors to which fatigue life is not very sensitive. Polishing the outside of the tubes with 180 to 320-grit emery paper, or burnishing on a Medart straightener, had no effect. Other things being equal, welded and redrawn tubes had the same quality as the seamless tubes. Varying grain sizes from A.S.T.M. No. 9½ to 5 did not affect fatigue strength (Fig. 8) nor did incomplete recrystallization of a weld bead in welded and redrawn tubing (Fig. 10 and Table I). However, this latter information is not conclusive since only a single test was made; undoubtedly some recrystallization, difficult to define, is necessary.

**Summary** – Three major factors affect the service life of tube systems; they must be controlled to obtain satisfactory results. First – and most important – is the flattening which occurs at the bend when the tube is formed. When this effect is kept below 5% by careful shaping, the service life is raised appreciably. Surface roughness, particularly on the inside, is the second factor; as of now, only tedious quality control methods can keep this within reasonable bounds. Third, specified tensile strengths must be maintained.

*Fig. 10 – Incomplete Recrystallization Did Not Affect Fatigue Life in This Welded and Redrawn Tubing. Electrolytic oxalic acid etch, 50x*

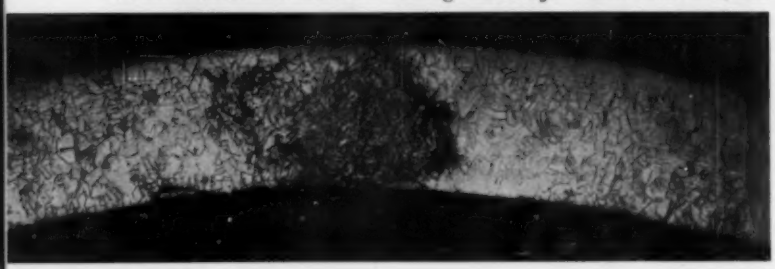


**Table I – Effect of Incomplete Recrystallization on Fatigue Life***

| Straight Tubes | | Formed Tubes |
|---|---|---|
| Incompletely Recrystallized | | |
| 1720 kc. | | 85 kc. |
| 1020 not failed | | 114 |
| 2490 not failed | | 179 |
| 1740 not failed | Average | 126 |
| Completely Recrystallized | | |
| 690 | | |
| 900 | | 97 |
| 2000 | | 190 |
| 2500 | | 192 |
| 1520 | Average | 160 |

*Fatigue maximum stress is 40% of tube tensile strength; the ratio of minimum stress to maximum is 0.12.

# *Joining Problems Aired*

*Reported by J. L. McCLOUD**

**Service requirements for metal assemblies used in jet and rocket engines and in atomic applications are becoming more stringent. This has focused attention on improved methods for brazing and welding metals for high-temperature service. At the First Western Welding, Brazing and Heat Treating Conference, experts got together to pool their knowledge in the joining field. (K-general)**

THE GOLDEN GATE CHAPTER ⓐ sponsored a conference on welding, brazing and heat treating at Stanford Research Institute, Menlo Park, Calif., on March 27 and 28. It had the cooperation of the San Francisco and Santa Clara Valley Chapters of the American Welding Society and the Santa Clara Valley Chapter ⓐ. The attendance was nearly 300 and included people from 12 of the 14 western chapters.

The opening paper by L. F. Yntema, retired vice-president and director of research, Fansteel Metallurgical Corp., dealt with the analysis of welding problems in joining high-temperature metals. These metals, in Groups IV, V and VI of the Periodic Table, are columbium, tantalum, molybdenum and tungsten. Their melting points range from 2415 to 3400° C. While they can be joined by riveting and brazing, welding broadens their range of usefulness in structures.

Welding of these metals is complicated by their reactivity with air and their ability to form alloys with low-melting metals. Tantalum and columbium, having similar physical and chemical properties, are welded in similar fashion. They react with about all gases, except noble ones. Resistance, submerged-arc and inert gas are the types of welding used. In resistance welding, the pressure must be high enough to establish electrical contact but not so high that too small a resistance is produced between the parts being welded. The weld may cover a small spot, or may take the form of a seam. The depth of penetration can be controlled and, within reasonable limits, sheets of a wide range of thickness can be welded.

In the submerged-arc process, the work is completely immersed in liquid carbon tetrachloride. A carbon rod is one electrode and the work the other. Here "freehand" technique is advantageous for some work.

In the third process, a refractory metal tip,

*Consulting Editor, Los Altos, Calif.

preferably tungsten, melts the metal of the work in an arc shielded by an inert gas, usually helium. Edge joints, flat sheets, tube circumference seams are welded. The weld metal is generally softer than the work and may be cold formed, such as by peening, to match the work stock. A filler rod may be used.

### Molybdenum

While welding mechanics for molybdenum are similar to tantalum and columbium, its sensitivity to trace impurities, especially oxygen, is a problem. Recrystallized molybdenum is normally brittle and oxygen must be rigorously excluded. Oxygen of the order of 0.0001% raises the bend test transition temperature to 180° C. from −70 (the value for pure metal); nitrogen of 0.0035% raises the transition temperature to 30° C. and 0.02% carbon produces an effect of the same order of magnitude. This condition of purity is necessary on the surface as well as in the body of the metal. Pure argon or helium is essential. Welded molybdenum sheet is being used in the form of tubes, nozzles and flame holders. Figure 1 shows a welded molybdenum cup.

### Brazing for Reactors

P. Patriarca of Oak Ridge National Laboratory described "Brazing in Atomic Reactor Construction". The metals used are generally nickel alloys and generally contain boron.

Brazing is done in hydrogen, vacuum and inert gas atmospheres. Hydrogen must be dried to a −80° dew point. This is done by various steps, such as with a nickel-copper catalyst, palladium, activated alumina and hot zirconium sponge. The quality of the brazed joint is tested in a "T" specimen.

Pump impellers for liquid metal may be welded or brazed. Valves with cermet-to-metal joints are possible with brazing. Finned tubes are brazed, and nickel deposited by electroless plating is desirable because the nickel-phosphorus alloy produced brazes easily. In brazing uranium to protect against liquid sodium, silver appears to be the best brazing alloy. Nickel alloys are also good for use with sodium but should have a minimum of manganese.

### Welding Aluminum

The story of successful research to improve quality and reduce cost of welds in aluminum alloys was told by M. B. Kasen and A. R. Pfluger of Kaiser Aluminum and Chemical Co. in their paper "Chlorine Additions for High-Quality M.I.G. Welding of Aluminum Alloys".

M.I.G. means metal-arc inert-gas welding. The comparison of weld quality was illustrated by radiographs of seams made with and without addition of chlorine to the inert gas. The addition of chlorine cleared the seam of porous spots. These welds were multipass, flat position ones using Al-Mg plate and filler wire. The porosity may be due either to hydrogen gas or dross from oxides. This use of chlorine was suggested by its successful application in foundry practice.

With as little as 0.06% Cl in the shielding gas, the weld is much improved. This addition is best made directly into the arc area. Poor-grade wire (with oxidized surface) gives much better welds by this process. To show the extent of improvement, various contaminants were deliberately added and the amount of chlorine needed was tested. When 8.7 cc. per min. H was present in the shielded gas, poor welds appeared. However, addition of 3 cc. per min. Cl removed the unsoundness. With 1.3 cc. per min. propane, 1.5 cc. per min. Cl was required. With 1.4 cc. per min. water vapor, 3 cc. per min. Cl returned the welds to good quality.

A chlorine flow of 10 cc. per min. to the arc area through the contact tube of the welding torch was suggested as optimum. This is most conveniently achieved by passing 0.5 cu.ft. per hr. of a 95% Ar, 3% Cl mixture through the contact tube. Some equipment changes are required; the cost of conversion is of the order of $100 and chlorine costs about 5¢ per hour.

### Braze Cladding

Among the subjects brought up by Darwin Christofferson, welding engineer, Chicago Bridge & Iron Co., Salt Lake City, Utah, in discussing problems in petroleum and chemical pressure vessel fabrication, were applications for Horton-clad plate which is produced by vacuum brazing a sandwich-type structure.

To produce a stainless clad product this procedure is followed: The stainless sheets are coated with a parting compound to prevent solid-state diffusion and are placed back to back, exposing the two bonding surfaces. Mild steel backing plates are pickled and coated with a satisfactory brazing material by one of these methods: (*a*) laying foil on the surface; (*b*) metallizing; (*c*) spraying brazing alloy in a volatile carrier liquid. The clean stainless sheet is then placed on a coated backing plate; another

*Fig. 1 – Molybdenum Cup Made by Inert-Arc Welding. (Courtesy Fansteel Metallurgical Corp.)*

coated backing plate is placed on top to complete the sandwich.

The next step is to seam weld the edge. The important thing is to provide a vacuum seal and allow an adequate channel for free expansion of the cladding material. The edge seal is air tested for leaks and a vacuum is drawn. The vacuum prevents oxidation and removes gases liberated at elevated temperatures. It also serves as a means for getting intimate contact between the plates. After the sandwich is bonded, it is powder burned along each edge and the clad plate separated.

The process allows plates to be made in a variety of shapes such as circles, squares, internally channeled and other forms. It also gives a wide choice of materials. Mr. Christofferson reported that vessels have been constructed from clad materials utilizing many of the 300 and 400 series stainless steels, Inconel, Monel, nickel, the Hastelloys and even pure silver. Experimental plates have been made with cladding of copper, 70-30 Cu-Ni, Carpenter 20, titanium, zirconium and aluminum bronze.

**Brazing**

The use of brazing alloys for missiles was described by A. C. Cape, consulting metallurgist. These range from relatively low temperatures up to 3000° F. in some proposals. (This presentation will be the basis for an article in a future issue of *Metal Progress.*)

Brazing materials described by Mr. Cape fall into three basic categories: (*a*) those used at low temperatures, including copper and silver brazing alloys; (*b*) alloys for use at 1600° F. or higher; (*c*) new alloys which have unusual special properties.

Harry E. Lewis discussed dry hydrogen brazing of assemblies for electronic, aircraft and missile applications. Oxidation problems are completely eliminated except for those metals

containing titanium and aluminum in appreciable percentages. The elimination of oxides means no fluxes are required to reduce them. There is, therefore, no entrapped flux left in the joint, no corrosion problem because of residual flux, and no flux in areas that might be exposed to vacuum in a vacuum tube assembly.

In brazing heat resistant alloys, it is important to be familiar with the metal-metal oxide equilibria in hydrogen. This mean relating the dew points of the hydrogen atmosphere to the temperatures at which various metals are in equilibrium with their oxides. Under equilibrium conditions, the rate of oxidation of the metal by water vapor is equal to the rate of reduction of the oxide by hydrogen. If the water vapor content (dew point) should increase, while the temperature remains unchanged, the equilibrium is disturbed and the water vapor starts to oxidize the metal until equilibrium is restored. Conversely, by lowering the dew point, hydrogen (being in excess) will reduce the oxide in order to re-establish equilibrium.

A point brought out by Mr. Lewis was that whenever possible the brazing alloy should be located so that its flow into the joint will be aided by gravity. However, if the alloy can be kept close enough to a joint for capillary action to start, it will pull uphill into a joint. Grooves within a joint are excellent for the placement of the alloy prior to assembly.

The choice of heating method, according to Mr. Lewis, is either furnace or induction. Furnaces are used when the entire assembly is heated. Some complex stainless assemblies can be induction brazed in dry hydrogen without flux.

**Fabricating Nuclear Parts**

From the consideration of rather small light parts, interest switched to large rugged components used in nuclear power reactors and auxiliary equipment. R. E. Lorentz, Jr., Combustion Engineering, Inc., discussed the problems which were encountered in this type of fabrication because of:

1. Necessity to fabricate extremely thick plates and forgings.

2. Requirements for extremely close tolerance welding and machining of complex designs.

3. Need (in pressurized water applications) for cladding low-alloy plate materials and forgings, on portions comprising the inside surface of the vessel, with stainless steel to protect against contamination in service.

4. Difficulty of obtaining low-alloy material, in the heavy thicknesses involved, with improved resistance to the possibility of brittle fracture during hydrostatic testing and on start-up of finished units.

5. The requirement for high degree of cleanliness in the finished product which requires extensive atmosphere heat treating facilities.

6. The necessity of working out and proving, through extensive testing programs, the adequacy of all fabrication procedures, such as nondestructive testing, welding, cleaning, heat treatment. These must be prepared in the form of written specifications for approval.

**Brittle Fracture**

Earl Parker, professor at the University of California, told the story of brittle fractures in his paper "Welding Problems Involved in Ship Structures". These were brought to light by failures in World War II ships. Welding of ships was authorized as early as 1917 and in 1921 a 150-ft. ship was made by all-welded construction. By 1940 all ships under 300 ft. were constructed by welding.

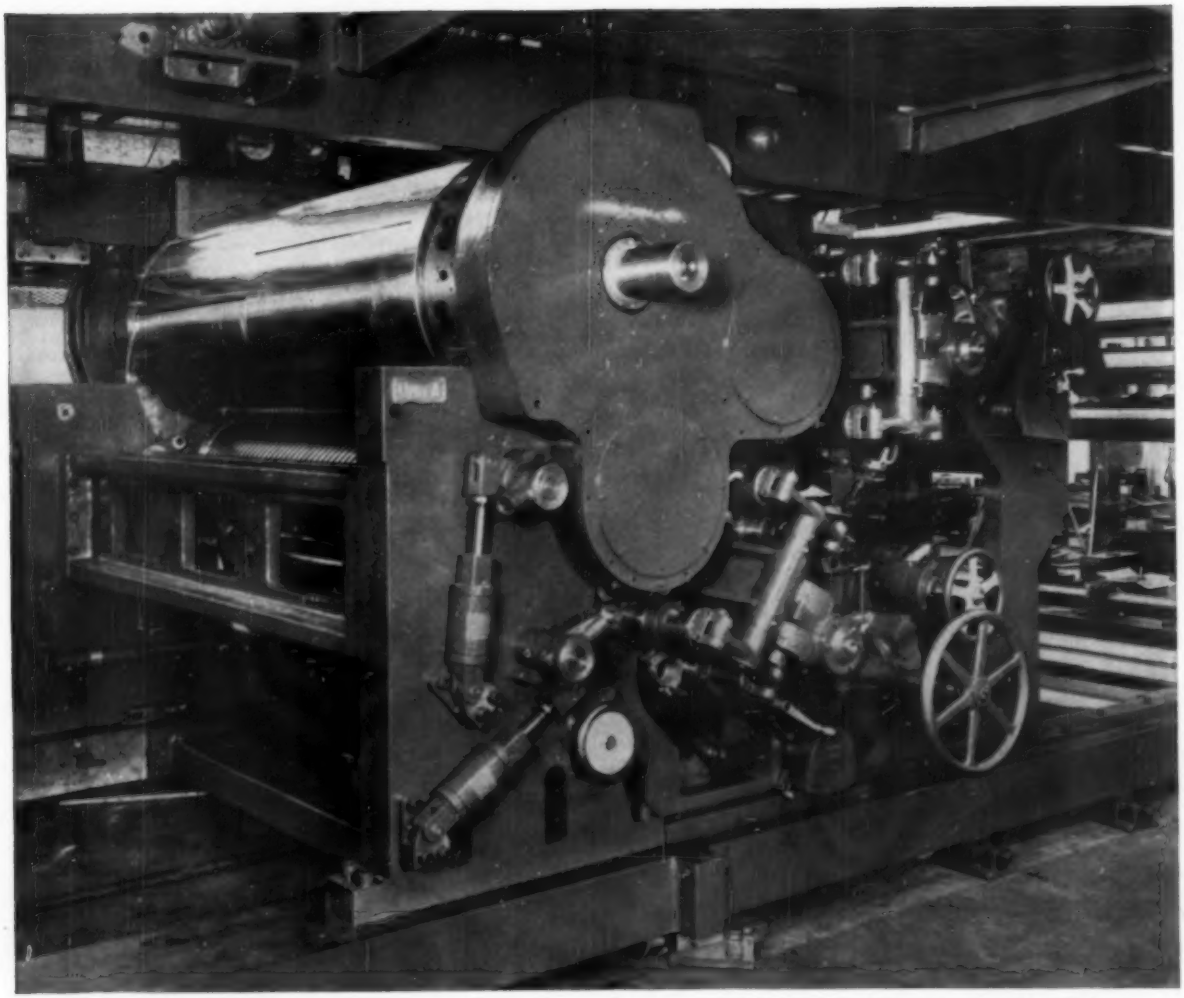
The first use of automatic welding was in 1940. Trained men and supervisors were scarce and some ten fractures occurred out of 400 ships built from 1940 to 1943. In January 1943 a T2 tanker split in two, even though the calculated stress was only 10,000 psi.

The failure was a cleavage (like mica slippage). It was similar to the brittleness shown in tensile test bars at −250 to −300° F. It takes tension stress to give these brittle fractures. Notches intensify the stress and with high tensile and low shear stress such brittle fractures occur.

Charpy V-notch testing shows up the brittle tendency of steels. When it is less than 15 ft-lb. at the temperatures encountered, brittle tendency is indicated.

It was reported that cold working increases the transition temperature and that different weld metals can make a significant difference, too. Pre and postheat treatment improves some weld metal joints.

Steel manufacturing practice also has an influence. With semikilled steels over ¾ in. in thickness, a lowering of the transition temperature from 25 to 0° F. occurs. European steelmaking practice, with lower finishing temperature, gives better steel for this work. In discussion, it was pointed out that peening on the last pass embrittles a weld but is advantageous on earlier passes.



New Babcock magazine press uses a ductile iron impression cylinder 50" diameter, 83" long. United Engineering & Foundry Company, Canton, Ohio, supplied this ductile iron casting to Babcock.

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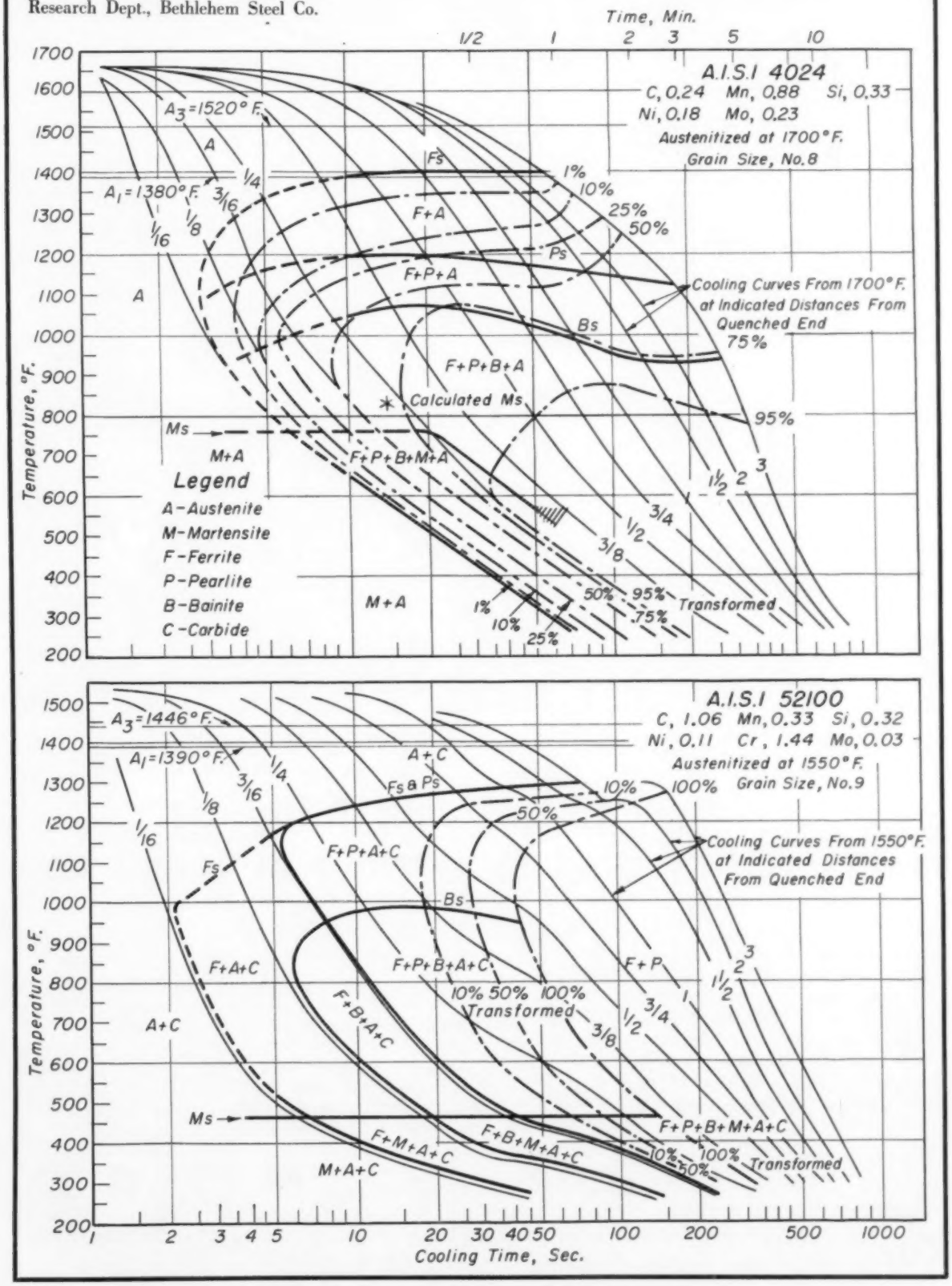
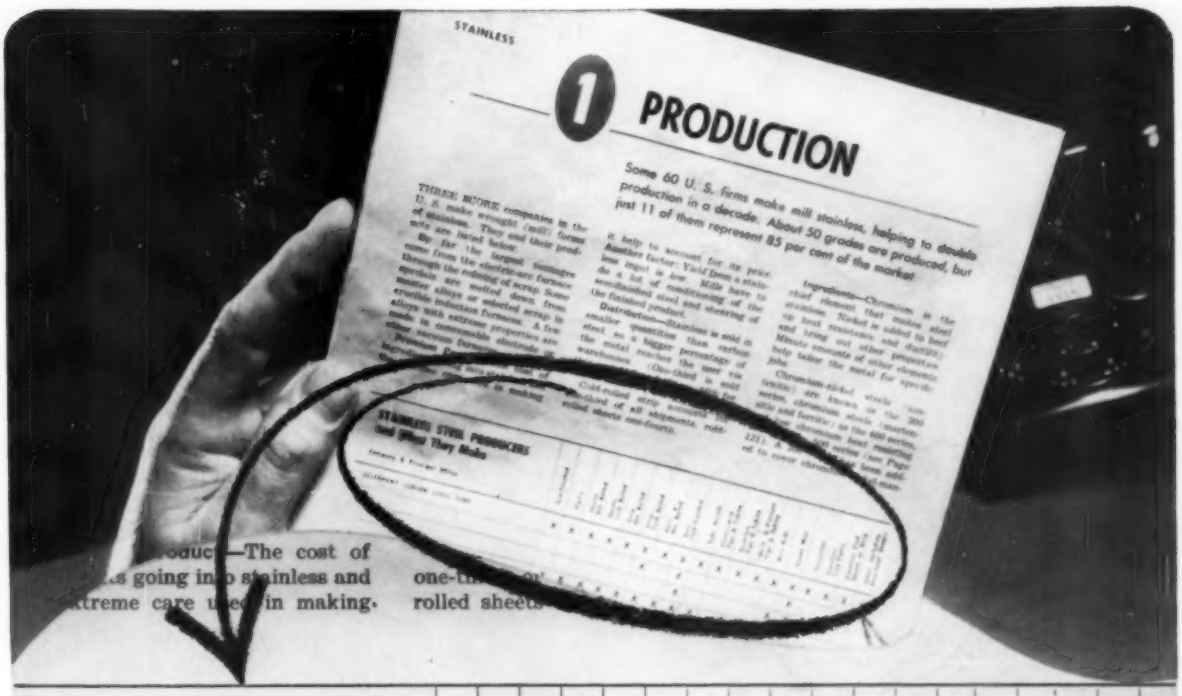
# Cooling Transformation Diagrams for A.I.S.I. 4024 and 52100

By R. C. Hess and D. J. Blickwede
Research Dept., Bethlehem Steel Co.




STAINLESS
1 PRODUCTION
Some 60 U. S. firms make mill stainless, helping to double production in a decade. About 50 grades are produced, but just 11 of them represent 85 per cent of the market
STAINLESS STEEL PRODUCERS and What They Make

| STAINLESS STEEL PRODUCERS and What They Make<br>Company & Principal Office | Semifinished | Plates | Sheets, Hot Rolled | Sheets, Cold Rolled | Strip, Hot Rolled | Strip, Cold Rolled | Bars, Hot Rolled | Bars, Cold Finished | Tube Rounds | Electricweld Pipe & Tubing | Seamless Pipe & Tubing | Mech. & Pressure Pipe & Tubing | Wire Rods | Drawn Wire | Extrusions | Stainless Clad Plates | Stainless Clad Sheets or Strip | Other, Including Structural Shapes |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| ALLEGHENY LUDLUM STEEL CORP.<br>Pittsburgh | X | X | X | X | X | X | X | X | X | X | X | X | X | X | X | X | X | X |
| [illegible] | | | | | | X | | X | | | | | | X | | | | |

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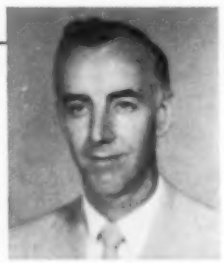

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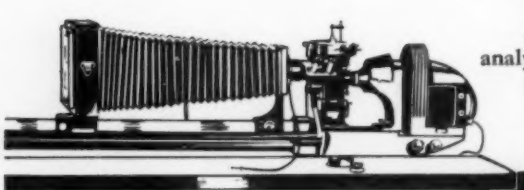

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# *Growth of the Titanium Industry*

*By PAUL M. TYLER**

**At a cost of six years' time, $250,000,000 of the Government's money plus nearly $100,000,000 of private capital, a complete titanium industry has been established in America. (A11a; Ti)**

FOR SOME YEARS titanium has been touted as the "wonder metal" in the daily and popular press – as well as in other magazines which might well have been a bit more cautious. Consequently, the recession of 1957 caused a corresponding reversal of sentiment and we now read that titanium is a "dismal flop" or a "great fiasco." In this series of articles, a sincere attempt will be made to place the *facts* on record so an intelligent engineer can decide the true status between these obvious extremes. It will be shown, I hope, that rapid industrial expansion started in 1951, encouraged by Governmental aid. Plants were built, quality of metal and alloy improved at rates closely conforming to long-range planning, and prices were lowered consistently. What would have taken a generation in normal metallurgical development was compressed into five or six years. This was too short a time to prove titanium's real value in many civilian uses. Practically all of the metal was bought by the Government; nearly all of the use was in fast aircraft, fighters and bombers. When this outlet was reduced by a "cut-back" or "stretch-out" in expenditure in the 1958 Federal budget, there was no place to put available metal. The recession became a depression, at least as far as the titanium industry is concerned.

So much for a 200-word summary. Now for the details.

### Historical Note About the Metal

Titanium was first used in the United States as a metallurgical deoxidizer – ferrotitanium (or, rather, ferro-carbon-titanium) being made at Niagara Falls in 1906. Pigment (titanium-white) came later (1918) but grew more rapidly; in 1956 about 500,000 tons of $TiO_2$ went into paint. Rutile (the oxide in its natural minerological form) began to be used in welding rods in the mid-30's.

Aside from a few pounds of high-purity metal, the production was less than 10 tons of commercial titanium in 1948, by Du Pont. This was made by reducing tetrachloride with magnesium, a process discovered in Luxembourg in 1938 by Wilhelm J. Kroll. The U. S. Bureau of Mines had investigated methods for reducing titanium since 1938 and in 1942 it concentrated on the Kroll process; by 1946, under the leadership of F. S. Wartman, its technical feasibility was demonstrated. U. S. Patent 2,205,854, covering the process, was originally assigned to a German company and was vested in the Alien Property Custodian in 1943. In 1951, Dr. Kroll, who meanwhile had emigrated to the United States, was awarded legal title thereto and the right to share equally with the Government in royalties from licensees. (The Kroll patent expired on June 25, 1957.) Meanwhile, the Du Pont Co. had constructed a pilot plant at Newport, Del., in 1948.

In the years prior to this, a good deal of work had been done in metallurgical research laboratories indicating that this potentially abundant metal, in addition to being light and corrosion resistant, could be alloyed for strength and creep resistance at temperatures where the common light metals, aluminum and magnesium, lost their usefulness. Wartime shortages of nickel and other important metals had emphasized the strategic importance of elements abundantly available within our own borders, and it was natural, therefore, that the Air Force, the Navy,

*Staff Consultant, Materials Advisory Board, Div. of Engineering and Industrial Research, National Academy of Sciences, Washington, D. C. This paper is the first of a series of three, summarizing Report No. MAB-47-SM, "General Review of the Titanium Metal Industry", dated Feb. 14, 1958.

and the Army all became interested in titanium alloys for military equipment.

A whole new industry to supply military and essential civilian needs was authorized by the Defense Production Act of 1950. At the time, the annual output in the United States was about 75 tons. Four important incentives were invoked in the titanium program, notably: (*a*) construction loans, (*b*) obligations of the Government to purchase, (*c*) accelerated tax amortization, and (*d*) grants for research and development. Other forms of governmental aid included much of the work done by the Bureau of Mines as well as research and development contracts financed by the Department of Defense. Under the Internal Revenue Code of 1954, all titanium ores mined from domestic deposits are allowed a depletion allowance of 23% of the gross income from the property (up to 50% of the net income). Two loans totaling $26,675 for exploration of ore supplies were also made to National Lead Co. by the Defense Minerals Exploration Administration. Fast tax write-offs were granted for rutile mining projects valued at $1,606,000.

**Sponge Manufacture**

Neglecting, for the moment, the rather intricate administrative setup to achieve the over-all objective of the Defense Production Act of 1950, it will be observed that that law called for a quick and large expansion in the production of titanium. At the time it was made only in Du Pont's pilot plant and 600 tons was the maximum annual output. The Defense Production Administration in March 1951 set an expansion goal of 7200 tons annually of sponge. The Minerals Advisory Board reported July 13, 1951, that 30,000 tons of titanium could be used to advantage in military items in 1953. The "conservative minimum estimate" for 1954 was predicted as 17,800 tons for jet engines (projected from contracts already let for 5500 tons in 1951), 6860 tons for airframes (based on known production schedules of five manufacturers) and 16,000 tons for army equipment. Since civilian demands were not to be expected in this short time, the total came to 40,660 tons. The expanding horizon is well illustrated by the following list of production goals set by the newly organized Office of Defense Mobilization:

June 30, 1951: 10,000 tons annually by 1953
Oct. 13, 1952: 22,000 tons annually by 1955
Aug. 6, 1953: 25,000 tons annually by 1956

The last-mentioned figure is still the official goal, although the Secretary of Defense in 1953 recommended production of 35,000 tons annually by 1956, and in 1954 the ODM was preparing to authorize contracts for a total of 37,500 tons.

Table I summarizes the present situation. Some notes on the governmental expansion will now be given.

*Fig. 1 – Manipulator Removing Large Titanium Ingot From Heating Furnace at Toronto (Ohio) Plant of Titanium Metals Corp. of America*

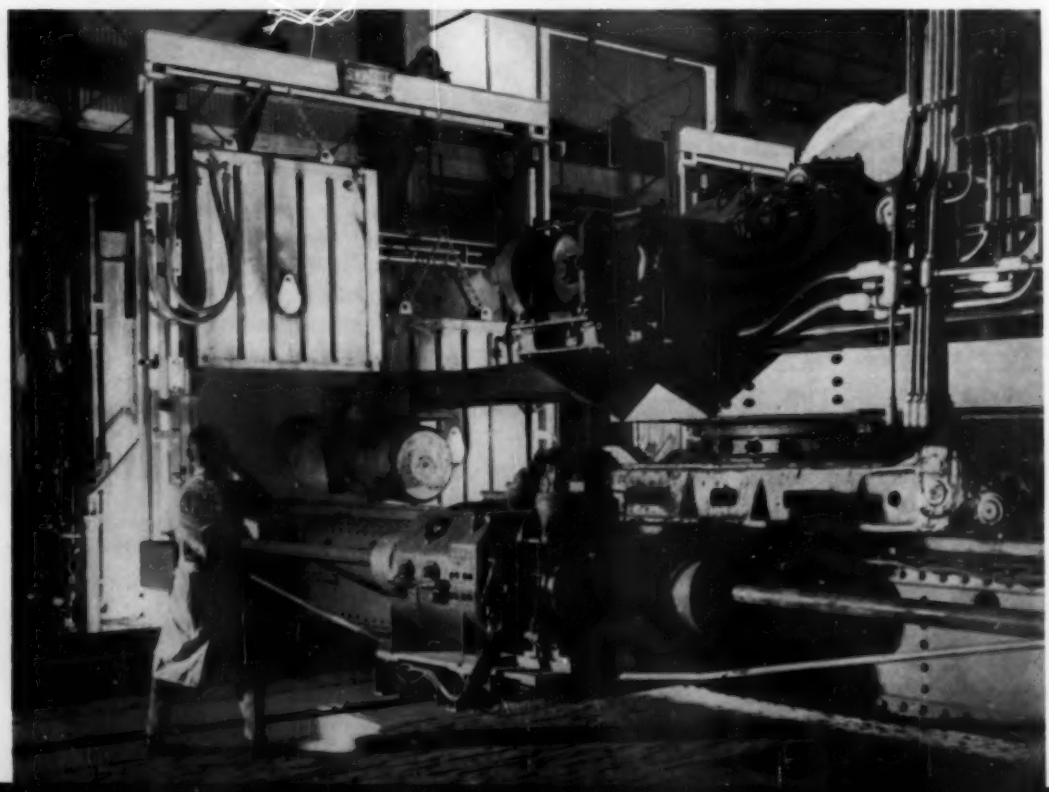

**Table I – Manufacturing Capacity for Titanium Sponge (Short Tons, as of Sept. 30, 1957)**

| Company | Plant Location | Expansion Program *(a)* | | Private Expansion | | Total Scheduled Capacity | Installed Capacity Jan. 1, 1958 |
|---|---|---|---|---|---|---|---|
| | | Capacity | Start | Capacity Scheduled | Start | | |
| Titanium Metals Corp. of America | Henderson, Nev. | 3,600 | 1951 | 5,400 | 1956 | 9,000 | 7,000 |
| E. I. du Pont de Nemours & Co. | Newport, Del. | 2,700 | 1953 | 3,600 | 1957 | 7,200 | 5,400 |
| Dow Chemical Co. | Midland, Mich. | 1,700 | 1954 | — | — | 1,800 | 1,800 |
| Cramet, Inc. *(b)* | Chattanooga, Tenn. | 6,000 | 1955 | — | — | 6,000 | 6,000 |
| Electro Metallurgical Co. | Ashtabula, Ohio | 7,500 | 1956 | — | — | 7,500 | 7,500 |
| Mallory-Sharon Metals Co. *(c)* | Ashtabula, Ohio | — | — | 5,000 | 1958 | 5,000 | — |
| Total | | 21,500 | — | 14,000 | — | 36,500 | 27,700 |

*(a)* By Defense Production Administration and its successor, the Office of Defense Mobilization.
*(b)* A group consisting of Crane Co. and Republic Steel Corp.
*(c)* Merger of National Distillers Products Div. of U.S. Industrial Chemicals Co., P. R. Mallory & Co., and Sharon Steel Corp. to be an integrated producer of sponge, ingot and mill products.

An advance of almost $15,000,000 was made to the Titanium Metals Corp. of America; repayments lead to the belief that the ultimate cost to the Government will be $791,000. Deliveries have been 753 short tons.

Under the Du Pont contract, the Government advanced $10,340,000 and the loan has been completely repaid. The Government may end up with a profit of about $34,000 on the delivery of 179 short tons of titanium sponge. (On Sept. 13, 1953, the company abandoned plans for another plant at Johnsonville, Tenn., designed to produce 3600 tons per year.)

The Dow Chemical Co. contract called for no advance payments but the company delivered 978 tons to the Government in 1956 at an average of $9790 per ton. Based on a resale valuation of $4000 a ton, the inventory loss plus miscellaneous costs is estimated at $5,684,000.

Cramet, Inc., received $24,950,000 under its contract. The anticipated inventory loss on purchases of 4357 tons of sponge at an average cost of $8964 and future purchase of 1643 tons at $8880 per ton has boosted the probable ultimate cost to $36,037,000 for a total of 6000 tons of sponge.*

The last contract (with Electro Metallurgical Co.) obligated the Government to buy whatever metal the company was unable to sell in the commercial market; up to 7500 tons a year for five years. An escape clause was invoked early in 1957. It is expected that 8607 tons of sponge will be delivered, and the probable ultimate cost, including cancellation and depreciation, is estimated at $28,757,000.

The two remaining firms listed in Table I are installing their plants with their own capital.

The entire production of sponge should include another item: 160 tons costing $640,000 produced under contract at the U. S. Bureau of Mines' pilot plant at Boulder City, Nev.

The grand totals up to Sept. 30, 1957, then, amount to deliveries of 16,677 tons of sponge at a direct cost of $71,875,000. This figures to $4300 per ton or $2.15 per lb.

All five firms in the expansion program were granted rapid tax amortization for their expanded facilities, costing $81,435,640. Ninety per cent or $73,292,076 was certified up to suspension date, September 1955.

To be included in estimating cost of sponge should be three research contracts made by General Services Administration on sponge production at a total cost of $2,752,000. Three other contracts with the U. S. Bureau of Mines for investigating various phases of raw material treatment cost $726,000.

### Melting and Processing Facilities

It can be seen from the above that sponge production increased as planned from 75 tons in 1950 to 14,595 tons in 1956, with every assurance that it would reach 40,000 tons in 1958. Noteworthy, too, was the improved quality; early contracts called for sponge of Brinell 225 maximum, whereas nearly all commercial sponge now produced is Brinell 100 to 120.

Figure 2 shows that the domestic output of titanium mill products has lagged behind produc-

*In March 1958, this company, having fulfilled its obligations, relinquished the plant to the U.S. Government.

tion of sponge metal. In 1954 it was only 1294 short tons. As techniques improved, melting capacity was increased so that, in 1956, 11,688 tons of ingots were produced by melting 10,936 tons of sponge and 2033 of scrap; consumption of ingots was reported as 10,860 tons. Melting capacity was expected to exceed 30,000 tons, roughly matching sponge capacity, by the end of 1957, and the revised estimate on Dec. 31, 1957, was 32,400 tons of ingots a year.

Cutbacks in defense requirements announced in May 1957 caused a steady decline of production of both sponge metal and mill products. Quarterly figures for 1957 follow, in short tons:

| | Sponge Produced | Sponge Consumed | Mill Products |
|---|---|---|---|
| 1st quarter | 5897 | 4013 | 2048 |
| 2nd quarter | 4846 | 2821 | 1930 |
| 3rd quarter | 4205 | 1161 | 1105 |
| 4th quarter | 2315 | 226 | 375 |

Some idea of the distribution and cost of the melting and fabricating capacity may be had from the "Titanium Report of the Attorney General" dated May 9, 1957, showing the certificates of necessity issued to the various companies authorizing accelerated tax amortization:

| | Melting Plant | Mill |
|---|---|---|
| Rem-Cru (*a*) | $ 6,014,033 | $ 7,228,000 |
| TMCA group (*b*) | 5,287,930 | 14,617,000 |
| Cramet group (*c*) | 10,130,000 | 400,000 |
| Mallory-Sharon group (*d*) | 4,177,114 | 4,875,508 |
| Others | | 4,916,376 |
| Total | $25,609,077 | $32,036,884 |

(*a*) Originally Remington Arms (Du Pont subsidiary) and Crucible Steel Co. of America; (*b*) Titanium Metals Corp. of America, National Lead Co., and Allegheny Ludlum Steel Corp.; (*c*) Crane Co. and Republic Steel Corp.; (*d*) P. R. Mallory & Co. and Sharon Steel Corp.

**Revolving Stockpile**

Owing to the anticipated delay in balancing sponge production with melting capacity, the Defense Production Administration authorized Aug. 30, 1951, the establishment of a temporary revolving stockpile program geared to the commitments for purchase of sponge. Five million dollars was provided for purchase and resale of 1,000,000 lb. at prices not to exceed $5 per lb. This authorization was progressively extended and the authorized quantity raised as needed.

Up to June 1954 only 303 tons had been bought according to this plan, and it was resold at no loss other than about $7000 for handling. By Sept. 30, 1955, however, General Services Administration had purchased 2642 tons from Du Pont and 2682 tons from Titanium Metals Corp., as well as 93 tons from Cramet and Wah Chang Corp. The Govertment inventory then totaled 5351 tons of sponge, costing $47,282,000.

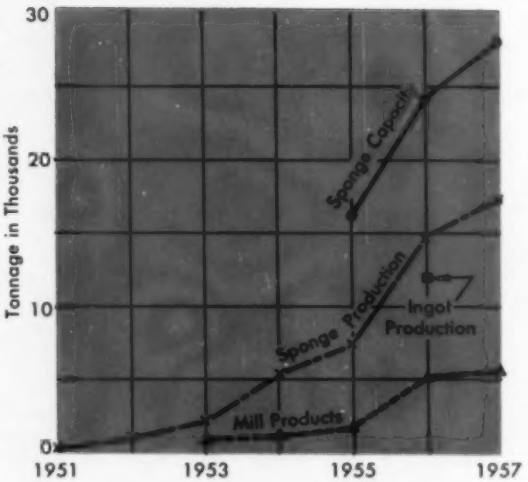


*Fig. 2 – Capacity and Production of Titanium Sponge and Tonnage of Mill Products, 1951 to 1957 Inclusive*

The tonnage in the revolving stockpile increased from 6647 on Dec. 31, 1955, to 9316 at the end of 1956 and to 17,565 tons on Sept. 30, 1957. At that time, the total cost of the sponge was reported as nearly $134,000,000 and the market value, figured at $2 per lb., was $70,300,000, indicating an inventory loss of around $63,500,000. The ultimate total in the stockpile, based on current commitments and assuming no more resales, is expected to reach about 22,000 tons, of which 2500 tons or more may be over Brinell 140 in hardness.

To those tonnages should be added sponge metal made in Japan and received under barter agreement with Commodity Credit Corp. Scheduled annual shipments are 1500 tons, and a total of 8907 tons will be delivered on completion of the agreement (Dec. 31, 1961). Assuming no withdrawals, the inventory may then be on the order of 31,000 tons, or a little over one year's capacity output.

While titanium sponge was included in the list of materials for acquisition in the national stockpile on July 16, 1954, none has been so credited up to the end of 1957. All the above American production is held in inventory and the Japanese is debited to the Commodity Credit Corp.'s account. *(Continued on p. 170)*

***Staff Report***

# *Getting More From Metal Powders*

**Powder metallurgy holders for carbide tools look promising; metal powders solve barrel finishing problems; slip casting expands potential for large, complicated parts from powders. These were among the new developments reported at the annual meeting of the Metal Powder Association. (H-general)**

SOON YOU MAY BE using powder metallurgy bodies to hold carbide or ceramic cutting tools employed in machining operations. Outstanding advantages of holders made from metal powders, in addition to lower cost, is their valuable effect in dampening vibrations induced in the cutting elements as they enter the cut.

This is one of the new applications for powder metallurgy which came to light at the annual meeting of the Metal Powder Association held in Philadelphia recently.

Horace Frommelt, director of Spring Garden Institute's Metal Removal Center, Philadelphia, told the opening technical session: "Three years of test results and laboratory work prove the value of the powder metal technique, both technically as regards the machining process and economically in cost."

The powder metal-carbide technique involves the following steps: The briquette is formed in a die as usual, with a slot for the carbide formed by a portion of the die or punch. At the briquette stage the carbide is inserted manually. The dimensional relationship between the slot and the carbide thickness is such that a gentle manual fit is required. The assembly is then infiltrated with copper which locks-in the carbide. The metal powder, by virtue of expansion of the mass, shrinks the aperture around the carbide, thus holding it in place mechanically. Mr. Frommelt emphasized that there is no brazing between the carbide and the powder metal because of the copper infiltrant.

The design of cutting tools using powder metal inserts can be varied to suit the limitations of powder metal as well as the conditions imposed by the cutting field and techniques. For example, a face mill may be of ductile iron or steel using powder metal inserts. Or a face mill may be used whose central core or body is made of steel with a supporting powder metal ring having slots for locking-in powder metal indexable inserts. In one instance these inserts were designed in such a way as to permit the use of eight cutting edges in one insert. Thus, indexing can take place four times on one end of the square parallelogram and, by reversing, four times on the other. According to Mr. Frommelt, the total cost of this insert is less than that for any other type of indexable cutter.

The modulus of an infiltrated piece of powdered iron is similar to that of a carbide pad or bar based on vibration characteristics. This dampening effect is extremely beneficial for edge

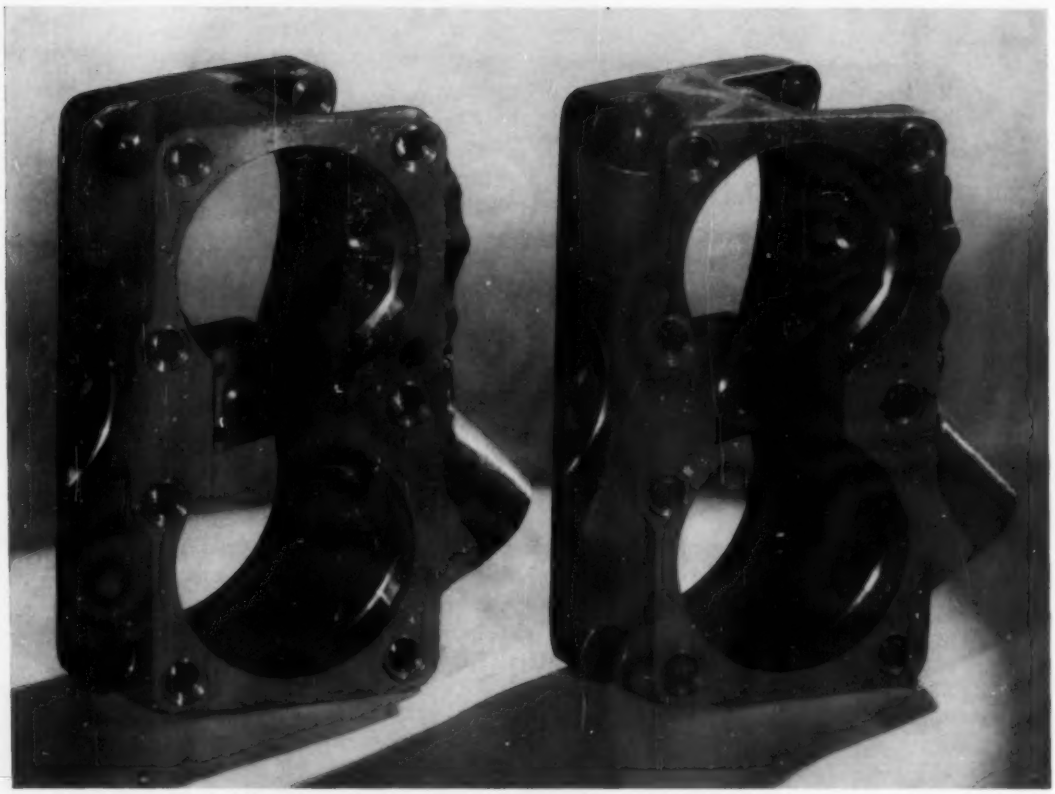

*Fig. 1—The Metal Powder Tumbling Medium Shown Lodged in Threaded Holes of the Aluminum Casting (Right) Was Removed by Dipping in Acid to Dissolve the Metal Matrix. (Courtesy Bendix Aviation Corp.)*

life, Mr. Frommelt pointed out. Much the same result is true of vibrations induced in milling cutters. Tests have shown a remarkable increase in tool life when these cutters are run at the same surface foot rate as steel-bodied cutters. The combination of lower manufacturing cost for the bodies and holders plus the desirable dampening effect makes the metal powder method an enticing new technique for the metal cutting field.

**Barrel Finishing With Metal Powders**

Complex aluminum castings used in aircraft fuel systems caused trouble in the barrel finishing department at Bendix Products Div., Bendix Aviation Corp., South Bend, Ind. The internal, cast-in channels in these parts trapped the barrel finishing medium and made removal difficult. Bendix's G. C. Madigan told of studies which led to the development of tumbling media which consist of a blend of copper metal powder and abrasive formed into pellets by pressing in a die and sintering. After tumbling, pellets may be dislodged by placing the casting (Fig. 1) in an acid until the pellets drop free.

Test work indicated that a metal matrix impregnated with an abrasive had other advantages, as well as aiding in the removal of lodged particles. The new media appeared to form small radii more rapidly than previous media. Wear life also seemed to be better. Experiments were conducted to develop a composition which seemed best suited for the variety of metals to be tumbled.

Figure 2 shows a 356-T 6 aluminum casting finished in a metal powder medium. A fine radius was obtained on the edges after tumbling for 30 min. The surface roughness was reduced from 80 to 20 root mean square. These surfaces make such castings suitable for use as gasket and "O" ring seals.

Another example cited by Mr. Madigan involved finishing parts of Type 416 stainless having a hardness of Rockwell C-30. Large burrs were removed by tumbling using the metal powder medium and the part was then finished in a brightening compound. The previous production process required a hand operation to remove heavy burrs and a barrel finish to radius the

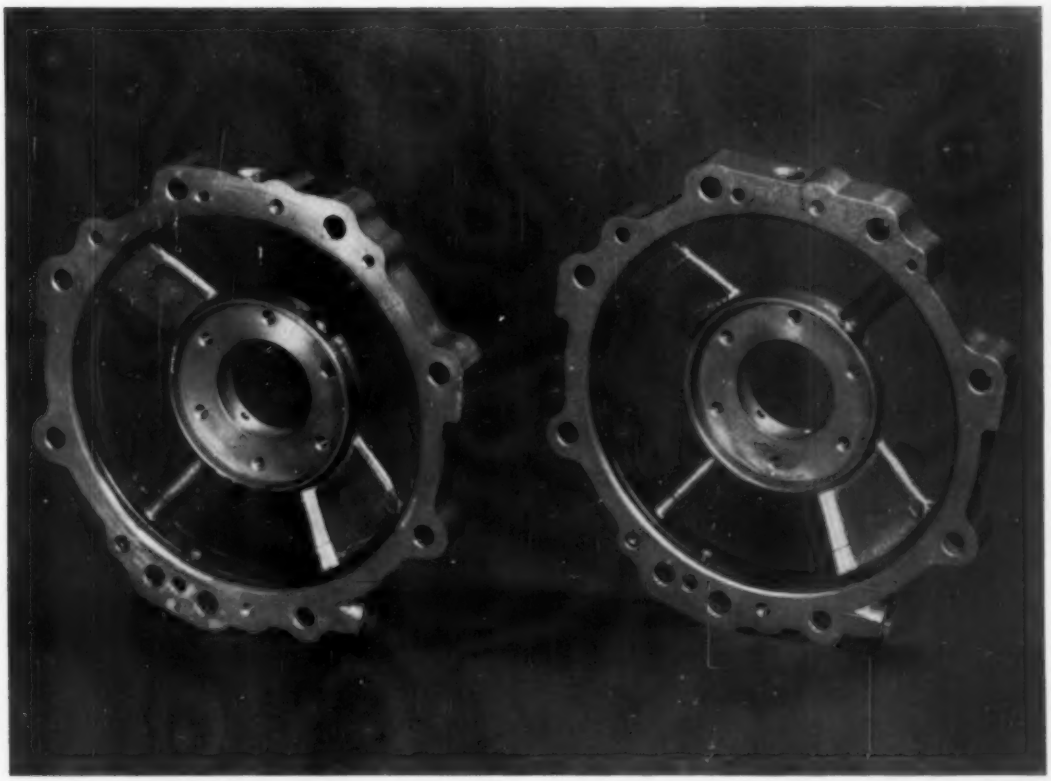

*Fig. 2—A 376-T6 Aluminum Casting Before (Left) and After Barrel Finishing With Powder Metal. The machined surface finish has been reduced from 80 to 20 rms. and all burrs were removed. Surfaces are suitable for use as gasket and "O" ring seals. (Courtesy of Bendix Aviation Corp.)*

edges. The surface finish on the part entering the barrel was 45 rms. on the flange and 120 rms. on the shaft. After finishing, the flange face was 20 rms. and the shaft 30 rms.

Mr. Madigan predicted that further work will result in a metal powder suitable for wide use in barrel finishing. A large range of metal and abrasive combinations is possible, so that media can be tailor-made for use in unique finishing applications.

**Slip Casting**

Metal powders can be slip cast for fabrication of parts which are too complicated or too large to make by conventional powder metallurgy methods, according to Henry N. Hausner, a well-known consultant. Dr. Hausner explained that the metal powder slip casting process does not require dies or compacting presses. He showed a stainless steel plate which, when fabricated by conventional powder metallurgy methods, would require a $6000 hardened steel die and a 1200-ton press for compacting. When made by slip casting stainless steel powders, all that was required was a mold which cost less than $30.

Slip casting utilizes a dispersion of metal powder particles in a liquid. Chemicals are added to prevent nonuniform settling of the particles. The slurry (slip) formed in this way is characterized by the metal-to-metal ratio and by such things as viscosity and pH — quite new variables in the powder metallurgy process, Dr. Hausner pointed out. The sintered densities of slip cast metals are in the same range as those of conventionally prepared powder metallurgy parts; however, grain structures are different and this can give improved physical properties.

Dr. Hausner foresees the application of slip casting methods for the fabrication of fuel elements, control rods and other nuclear reactor components. Additional applications in refractory metals and metal ceramic combinations are under investigation. He emphasized that slip casting will not replace conventional pressure compacting, but rather will enlarge applications for powder metallurgy.

Metal powder techniques can be utilized profitably in the production of highly competitive, low-cost items such as nuts and washers. This was the point made by P. V. Tarr, Midwest Sintered Products Corp., as he reviewed the production methods and distribution concept of sintered brass nuts. He reported that nuts are made from brass powder with clean detail to reasonable tolerances and maintain an "as-sintered" average ultimate tensile strength of 30,000 psi.

**Sintering Atmosphere**

For consistently good sinterings, watch the atmosphere that is used. It may be a source of unexplained inconsistencies, which can result in scrap losses and unnecessarily high production costs. This advice was given by E. P. Kawasaki, Republic Steel Corp., Cleveland, in his presentation dealing with the effect of sintering atmospheres on the properties of sintered iron compacts.

He presented data covering these points:

1. Highest tensile strength in iron compacts is always obtained by sintering in a carburizing atmosphere. This is particularly true when sintering compacts to which graphite has been added. The limitation is that the carbon potential of the atmosphere not exceed 0.85%, in which instance a weaker and more brittle hypereutectoid structure will result.

2. Carburizing atmospheres reduce the elongation characteristics of compacts by their carburization.

3. If no carbon is added to iron compacts, they will shrink considerably more (or grow less) during sintering with atmospheres of high carbon potential. The reverse is true if graphite is an integral part of the sintering because the decarburizing atmospheres, hydrogen or raw exothermic gas are responsible for more shrinkage (less growth) than the carburizing atmospheres.

Mr. Kawasaki pointed out that a growing trend in the metal powder industry is the addition of graphite to iron without copper additions. Copper is higher in price than carbon and it takes considerably more to increase the strength of iron powder parts than it does with carbon. According to Mr. Kawasaki, the optimum strength of iron-carbon sinterings occurs at slightly less than eutectoid carbon composition, that is, at about 0.70 to 0.80% carbon, assuming eutectoid at 0.85% carbon.

The proper method to handle iron-carbon mixes is to add the correct amount of carbon to the compact and then sinter in an atmosphere which has the same carbon potential as the carbon content desired in the final sintering. It is important to keep in mind that iron powders contain a certain amount of iron oxides or unreduced iron. Part of the carbon will go to reduce these oxides and will be unavailable for forming cementite with the iron. At sintering temperatures, the stable carbon gas is carbon monoxide, so stoichiometrically, one atom of carbon will react with one atom of oxygen to form one molecule of carbon monoxide. On a weight basis it then requires carbon equal to ¾ of the weight of oxygen present to react with the unreduced iron. The oxygen content of the powder can be closely approximated by the hydrogen loss. The correct amount of carbon to add then is, in terms of percent, ¾ of the hydrogen loss plus 0.85%.

Mr. Kawasaki said this formula works well in the laboratory if sintering is done in a gas with a carbon potential of 0.8. As noted above, he also emphasized that tests have shown that the physical properties of sinterings are less desirable when the carbon content exceeds the eutectoid composition.

**Change in Association**

A new organization, known as the Metal Powder Industries Federation (M.P.I.) was approved at the meeting of the Metal Powder Association and succeeds it. The M.P.I. will include four trade divisions: Metal Powder Producers Association; Ferrite Manufacturers Association; Metal Powder Core Association; and Powder Metallurgy Equipment Manufacturers Association. Because most uses for metal powders involve the science of powder metallurgy, M.P.I. includes a technology division which will function through the newly created American Powder Metallurgy Institute. Its main responsibility will be in the area of technical development with provisions for market research, too. The Institute has equal status with the trade divisions as part of the Federation. Elected president of the Metal Powder Industries Federation was George A. Roberts, vice-president of Vanadium-Alloys Steel Co., Latrobe, Pa., who has just completed a term as president of the Metal Powder Association.

The technical program at the Philadelphia meeting also featured a panel discussion on atmospheres for sintering metal powders. This will be reported in a future issue of *Metal Progress.*

# *Heat Treating Affects Aluminum Extrusions*

*By J. K. McLAUGHLIN**

**Aluminum extruders like to "homogenize" 6063 aluminum billets before extruding (this raises the strength of the product). This treatment is discussed along with the quantitative effects of several variables. (J21; F24; Al-b)**

THE MARKET for aluminum extrusions is quite large; in fact, about 25% of the aluminum products shipped are in this form. Our investigations have shown that most fabricators prefer 6063 aluminum for extrusion purposes since it is easily worked, has an attractive appearance, and is amenable to heat treatment. However, we have also found that procedures vary from plant to plant – to such an extent, in fact, that extrusion might as well be considered an art rather than a science.

To begin with, the alloy is a precipitation hardenable type, the hardening agent being magnesium silicide ($Mg_2Si$). Normally the metal is heated to 850° F. for extruding; recently, however, extruders have become interested in "homogenization" as a method for improving the mechanical properties. This requires heating to 1050° F. for better solution of the magnesium silicide. The material must then be quenched to 850° F. since it is too soft at the higher temperature for good extrusion. No matter which solution treatment is used, the extrusions are aged at 350° F. to obtain the desired properties.

At any rate, little is known concerning the effect of homogenization – in fact, practically no information is available in print. This may account for the numerous variations in operation procedures. With this in mind, we sponsored research which was planned to determine quantitatively the effect of this new method of heat treatment. The information may make it possible to standardize extrusion procedures.

## Experimental Procedure

The work started with the procuring of billets (termed "logs") from each of four suppliers; all logs were 5 in. diameter, direct chill cast 6063 aluminum. One supplier also included two custom-homogenized logs. Charging, melting, casting, homogenizing, and pre-extrusion practices were all investigated. The extrusion process itself was not considered since we felt that while actual values might change, trends established by the previous operations would not. To determine the homogenization effects – which were thought to be the most important factor – the temperature of 1050° F. was maintained within a narrow range while heating rates and holding or cooling times were varied between wide extremes.

Slices were cut from each of the billets, and processed for spectrographical analysis, macroetching, hardness tests, and microstructure, both transverse and longitudinal. As can be seen in Fig. 1, the as-cast structure varies from producer to producer. After hardness testing in the as-cast condition, sections were held at 1050° F., quenched in cold water, and again hardness tested. These same specimens were then aged at 350° F. for 17 hr. to develop the "T 6" (solution

*Magnethermic Corp., Youngstown, Ohio.

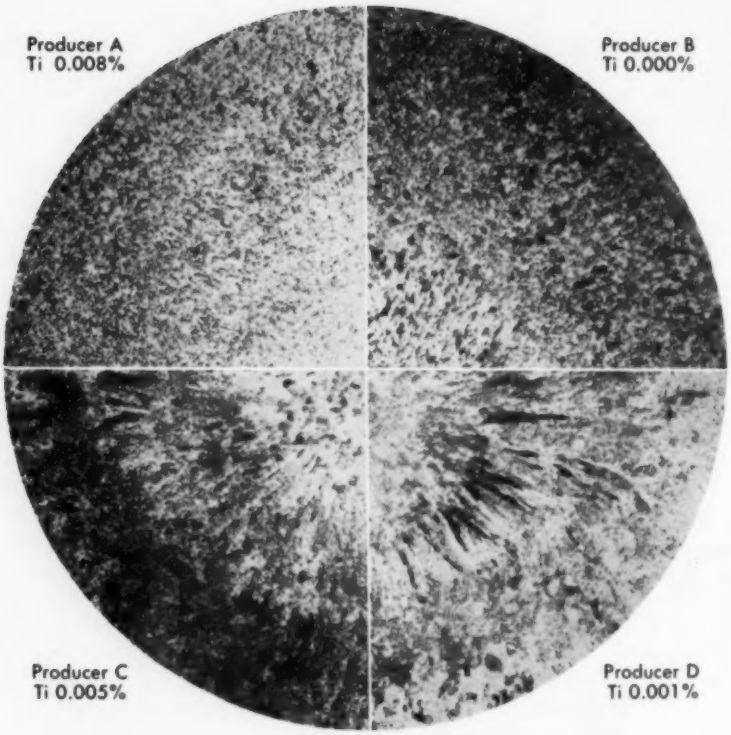


*Fig. 1 — Macrostructures of As-Cast Billets From Four Producers. Titanium refines the grain; hardness, in turn, is affected by variations in grain size*

treated and aged) condition. Hardness tests after aging were then compared with those obtained for the as-cast and water quenched conditions. Since the correlation of all these hardness data with the analyses and other factors presented a tremendous amount of mathematical work, the multiple correlation* technique, familiar in statistical work, was used. By this means, it was possible to separate the effect of each individual element on the hardness. The curves shown in Fig. 2 and 3 illustrate these effects.

The nominal composition of 6063 is 0.20 to 0.60% Si, 0.45 to 0.90 Mg, and aluminum. Iron, manganese, and titanium also affect the hardness; they are limited to maximum values of 0.35, 0.10, and 0.10%, respectively. The curves reveal that, as might be expected, $Mg_2Si$ in increasing amounts raises the hardness. Excess silicon also raises the hardness, but is not desired since it also lowers the corrosion resistance. The resid-

*This deserves a special note since multiple correlation was carried out graphically, not by calculation as is customary. For this investigation (and also speaking in mathematical terms), the dependent variable was the "T 6" hardness while the independent variables were the element percentages, sample position, and producer.

After compiling data, one of the constituents was chosen, and hardness plotted against it. If this were the only variable, all points would lie on a curve — perhaps even a straight line. Since it wasn't, a first approximation of the curve was made, all points above and below this line being assumed as the effect of other variables. When the next constituent was chosen, the *deviations* from the original line were plotted against it. This continued until all variables were taken into account.

The process is repeated until deviations are minor and curves are well defined.

*Fig. 2 — Hardness Variations in Solution-Treated and Aged 6063 Aluminum. Magnesium silicide ($Mg_2Si$), silicon and iron all increase the T 6 hardness*

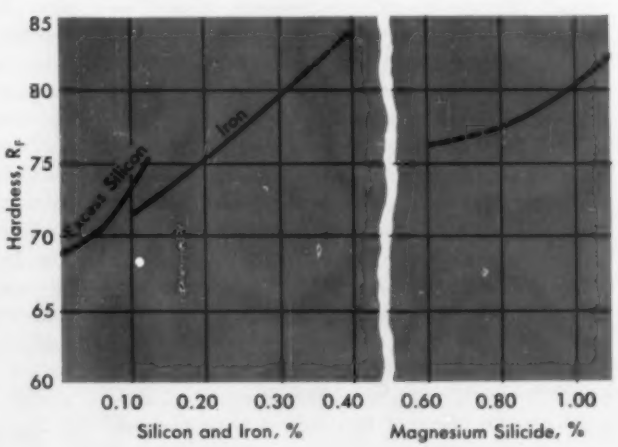

**Table I – Effect of Homogenization on T6 Hardness**

| Composition* | | | Rockwell F Hardness | |
|---|---|---|---|---|
| Excess Si | Iron | Ti | Predicted† | Actual |
| 0.14 | 0.123 | 0.016 | 62.0 | 78 |
| 0.14 | 0.112 | 0.015 | 59.5 | 77 |
| 0.12 | 0.100 | 0.015 | 54.1 | 75 |
| 0.14 | 0.157 | 0.016 | 63.5 | 78 |
| 0.13 | 0.102 | 0.016 | 68.5 | 77 |
| 0.13 | 0.112 | 0.018 | 55.4 | 74 |

*All samples contained 0.68% $Mg_2Si$, no manganese.

†Predicted value on a nonhomogenized billet.

ual elements mentioned increase the hardness as well, though the effect of titanium – which is added to refine the grain – drops off after 0.005% is passed.

Hardness also varies with position in the billet (this is attributed to the variations in grain size from surface to center – see Fig. 1) and with the producer. The latter variation may be caused by trace elements peculiar to the individual producer; these were not investigated. Copper, chromium or zinc in the amounts present did not affect the T6 hardness values. Neither did the total alloy content.

### Using the Curves

With these curves available, the correlation constant was calculated at −440; the T6 hardnesses of any samples from a given producer could then be predicted from their chemical analysis alone. The necessary values are obtained from the composition and the corresponding hardnesses obtained from the curves. The hardnesses are then added; subtraction of the correlation constant then gives the hardness of the solution-treated alloy.

**Table II – Effect of Heating Time and Methods on T6 Hardness**

| Heating Time, Min. | Rockwell F Hardness | | |
|---|---|---|---|
| | Distance Below Surface | | |
| | ¼ In. | 1¼ In. | 2¼ In. |
| Heated in Muffle Furnace | | | |
| 30.0 | 75.3 | 69.0 | 77.7 |
| 47.0 | 79.0 | 77.0 | 80.7 |
| 1380.0 | 80.3 | 81.7 | 82.0 |
| Heated by Induction | | | |
| 0.9 | 74.0 | 65.7 | 74.0 |
| 2.0 | 72.0 | 67.3 | 75.0 |
| 6.2 | 78.0 | 78.3 | 78.3 |
| 10.2 | 79.7 | 78.0 | 81.3 |
| 18.2 | 80.0 | 81.3 | 81.7 |
| 34.2 | 80.3 | 80.7 | 80.7 |
| 66.2 | 81.3 | 82.3 | 82.0 |

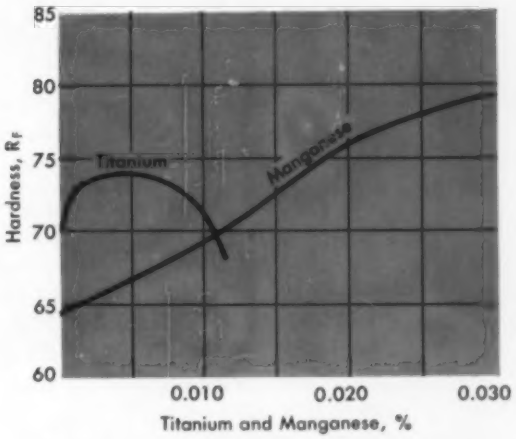


*Fig. 3 – Titanium and Manganese Increase the T6 Hardness. The effects of titanium are attributed to variation in grain size*

It now becomes possible to determine the effect of heat treating since variables imposed by the differing compositions can be eliminated. For example, a look at Table I will reveal the results of tests on some homogenized material. Compositions, predicted hardnesses, and actual hardnesses are listed; they show that homogenization has increased the hardness considerably. The finer, more even distribution of magnesium silicide due to homogenization produces higher properties. An interesting sidelight of this investigation concerns different heating methods. Most of the original work was done with a muffle furnace; to compare the effect of induction heating, similar samples were homogenized in both muffle and induction furnaces. All samples were heated at 1050° F. for the indicated times (Table II), water quenched, and aged at 350° F. for 24 hr. It is very apparent that induction heating is quite effective for homogenization, probably because the rapid heating allows a long time at temperature.

### Summary

The work outlined here is, we hope, of value to extruders of 6063 aluminum. Much remains to be done, but our findings concerning the effect of homogenization on mechanical properties of solution-treated and aged aluminum along with the quantitative effects of the several variables on hardness are of great interest.

# *Forecast of an Information Center*

*By MARJORIE R. HYSLOP**

**The A.S.M.'s research project at Western Reserve University (described in Metal Progress for February 1957) has progressed far enough to prove that penetrating searches of technical and scientific literature can be made electronically. The first commercial service will very likely be to send to individual subscribers information about documents appearing currently in any chosen portion of the metallurgical field. (A14e)**

SPUTNIK jarred the American public out of its complacent view of the Russians that they were a race of peasant farmers with embryonic industry (perhaps equal to what the West enjoyed at the turn of the century). Obviously this was wrong – they were actually ahead of us, at least in astronautics.

How did they get that way?

One widely publicized opinion was that they made the maximum use of foreign literature. The All-Union Institute of Scientific and Technical Information, which publishes excellent and inclusive abstract journals in 13 different fields, was said to have a regular staff of 2300 persons and part-time abstracting staff of 20,000. So immediately we heard many proposals – some examined with care by Congressional Committees – that something of the same sort be immediately instituted in America.

We could spend a lot of time on the details, merits and demerits of these plans and projects, but perhaps a better way to get down to specifics will be to tell what is being done and what is projected in the documentation of metallurgical literature.

### Metallurgical Documentation

For the purposes of this article, "documentation" is the group of techniques required to collect the published literature or recorded knowledge in a chosen area and make it available for prompt and efficient use. This includes such operations as storage, abstracting, indexing, searching and duplicating.

Metallurgy is a pretty well-documented area of engineering if we look upon it from the standpoint of conventional and traditional tools. That is to say, there are more abstracting services throughout the world which serve the field of metallurgy than there are for almost any other industry. Unfortunately, the mere existance of abstracting services no longer solves the documentation problem. The sheer bulk of the literature, the ever-increasing quantity of words and printed pages, make it a laborious and unrewarding chore to search even the abstracts for desired information. Furthermore, the indexes are poor and incomplete. How many of us have not picked up a volume of abstracts with the certain knowledge that the information we want lies somewhere in those pages – and then encountered complete frustration when we tried to locate it through the alphabetical index!

So it is in the area of literature *searching* – "information retrieval" is the expression used by the documentalists – that the need lies for new methods and techniques – techniques that will permit clerical help and machines to do the searching chore, thus relieving the engineer, researcher and scientist so his time can be more profitably spent on the technical problems.

Looked at from this standpoint, the field of metallurgy is again in a fortunate position. Mechanical searching techniques as applied to metallurgical literature are in a forward state of development. I think we can fairly attribute this to the foresight and acumen of the American Society for Metals. Our documentation activities are by no means new, and perhaps a bit of history and background is in order.

The *Review of Metal Literature* – an abstracting service – was established by the A.S.M. in 1944. The literature citations are not rightfully abstracts but rather annotations – they are indicative rather than informative. Their chief

*Managing Editor, *Metal Progress*. Adapted from an address on "Engineer's Day" at Ohio State University, Columbus, May 2, 1958.

features distinguishing them from other metallurgical abstracting services are their promptness of publication and their completeness of coverage of the field.

Shortly after the establishment of this literature review, the first stirrings of interest in mechanized control of literature were heard. The earliest evidence of this took the form of hand-sorted punched-card systems. These of course are hardly "machine" systems but they do introduce an element of mechanization and — more important — the principles developed for coding and for analyzing the subject matter to fit patterns of holes on the edges of a punched card are also adaptable to the patterns of holes in the center of a machine-sorted card, or the patterns of spots on a magnetic tape. At any rate, the American Society for Metals appointed a committee with which the Special Libraries Association cooperated, and the result was what is called the "ASM-SLA Classification of Metallurgical Literature" and a special punched card designed to use with it. This classification, appearing in 1950, has been so well accepted and adapted to so many other uses besides punched-card systems that a revised and expanded edition will be available this summer.

A hand-punched card works pretty well for small collections of literature references, and it is used principally by individual metallurgists to organize their own information files of periodical articles, books, internal reports or other documents. If as many as 10,000 items are to be indexed, the hand-punched card system becomes unwieldy, and this places a strict limitation on its use, so almost immediately attempts were started to adapt the ASM-SLA Classification to more highly mechanized devices such as business machines or digital computers. None of these were completely successful but they did encourage the ASM management to believe that "giant brains" of some sort could speed up and refine the searching operation on a grand scale.

**Research Program**

So a five-year $75,000 contract was signed in 1955 with Western Reserve University's Center for Documentation and Communication Research to determine the facts. The project has just passed the half-way mark and looks most promising. Three conclusions have so far been reached:

1. The key to mechanical indexing and searching lies not in the machine itself but in the method of subject analysis.

2. No machine now commercially available can do the job efficiently.

3. The greatest contribution of the machine lies not in speed (important though this may be) but in *effective* and *thorough* searching.

Development of the system of subject analysis to do this effective searching is not something which has been evolved in a hurry; formulation of the basic principles antedates the A.S.M. program by many years. The system has been designed on the premise that once the basic principles were worked out, a machine could be built to perform the required functions. To prove this point, the research staff at Western Reserve University built an experimental model (a slow-speed machine) which is now operating successfully on test searches. Bids on a commercial high-speed counterpart of this experimental machine are now being received from four manufacturers; it will not be cheap but it is only a small fraction of the cost of a general-purpose computer.

The third finding is possibly surprising but certainly important: The versatility and breadth and depth of indexing and searching that can be achieved with a machine system are far superior to anything that can be done by conventional means. For example, it offers quick interaction of concepts that might be widely separated in a printed list of alphabetical terms or in the conventional hierarchies of a classification system. It shows relationships that a printed list cannot — relationships of ideas, relationships of functions and relationships of specific and generic terms. Furthermore, it makes these associations *every time* — there are no "blue Mondays" when the searcher is a little forgetful or careless!

**Commercial Application**

So much for the experimental program. What of the future?

One service to industry can be made available as soon as a high-speed machine is built. This is the analysis and digestion of current up-to-date technical information on a regular basis, in a form tailored to suit the individual's needs.

Subscribers to this service would receive, month by month, or week by week, notification of all important documents occurring in technical and scientific periodicals in any chosen portion of the metallurgical field. The selected portion of the field might be broad or narrow; it might be the heat treatment of steel or it might be grinding stresses; the information provided would be selected to fit the exact requirements. It would

come in any form the subscriber might specify – as a list of published articles, as informative abstracts of the articles, or as copies of complete documents. Such a personalized service has not to my knowledge ever before been offered in any engineering or scientific field. It can be started at any time the entire current metallurgical literature is put onto machine feed, month by month.

This, of course, cannot be done without a certain amount of highly skilled labor. It is not solely a matter of pushing buttons. Nothing has yet been invented that will transform the ideas and concepts in a printed document into appropriate indexing terms which can be fed into a machine. Such an invention may not be beyond the realm of imagination, for routines have already been developed whereby a standard typewritten index term is automatically transformed into appropriate electrical impulses to actuate the machine. But certainly for some time to come we must rely upon human intelligence combined with thorough metallurgical knowledge to determine the appropriate indexing terms to characterize each document and each important fact or idea in it.

This brings us to the inevitable question of cost. It is much too early to even guess at what the subscriber will have to pay for the services of the Metals Information Center. We do, how-

**Book Review**

# *Study of Engineering Materials*

*Reviewed by DONALD S. CLARK**

PRINCIPLES OF THE PROPERTIES OF MATERIALS, by Jacob P. Frankel, McGraw-Hill Book Co., Inc. New York, 1957. 228 p. $6.00.

THIS BOOK serves as the basis for a sophomore course in Engineering Materials. In his approach the author emphasizes properties rather than materials. In this respect the book is not traditional – that is, all educators do not subscribe to this philosophy. However, many teachers of engineering materials agree with the author that it is more important to concentrate on principles rather than practice or techniques. One may say this is a more modern way of looking at engineering training. This approach becomes necessary because of the more scientific character and stringent requirements in engineering. While much of the practice of engineering is empirical, more of it can be approached from an analytical point of view. The student should have a good basic training in principles which will permit him to understand present practices and which will also allow him to tackle the more complex problems ahead. This is the general basis on which this book is written.

The entire approach to the subject is one of apparent sophistication. This reviewer believes that it is an attitude that should not be laid on so thick. The author has probably overemphasized the basic concepts without sufficient illustration to clarify the significance of the approach. In many instances he has not given the engineering significance of the properties being discussed. While the material that is presented is interesting, much of it could be expanded, particularly as to application.

*Dr. Clark is professor of mechanical engineering, California Institute of Technology, Pasadena, and immediate past president of

ever, have available some figures and estimates that indicate it won't be exactly peanuts. For example, we know that it now costs us $2.50 apiece to prepare the annotations which make up the *Review of Metal Literature*. Some calculations indicate that, to analyze a document for machine indexing and to prepare a really informative abstract, we will have to up this figure to about $10 apiece. At the present time the *Review of Metal Literature* is abstracting 12,000 documents per year. Supposing that a little discrimination is exercised to separate the really important metallurgical information, and assume that 10,000 documents per year is an adequate coverage, this makes a total of $100,000 a year to prepare the material. We can make a further assumption that it would take as much again to manage the enterprise, encode the digests and run the machine, which gives a preliminary estimate of $200,000 needed annually to operate a metals information center.

This only gives an order of magnitude. That the cost to an individual user will be less than he is now spending is almost certain. Many times $200,000 is now being spent throughout industry on this very job, with inevitable duplication and overlap. The real service of the Metals Information Center will be in the centralized, systematic and expert analysis and encoding. The machine will do the rest.

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The author states that the text is written with the general education of all engineers in mind and that it is intended that the material will be covered in a single semester's introductory course. The author assumes that before a student takes the course he will have completed at least one course in general inorganic chemistry and that he will be acquainted with the principles of atomic theory. He will also have studied physics, including mechanics. There is also an assumption that the reader has an introductory knowledge of calculus.

The book is written in two parts, of which the first is concerned with physical-chemical foundations. In five chapters the author deals, among other things, with some facts about atoms, equilibrium and thermodynamics, the structure of metals, thermal analysis, temperature, and heating curves. He also discusses briefly atomic bonds and band theory.

The second part of the book, concerned with properties, is covered in ten chapters dealing specifically with conductivity, heating, diffusivity, electrochemistry, elasticity, plasticity, fracture, viscosity; general considerations and a look ahead complete the presentation.

In the preface the author states that the book is a text and is not a treatise. He is most certainly correct that the book is not a treatise. However, one may also question if it is a text. A text is a complete story for the purpose of educating the reader in a particular subject. To this reviewer the book is too brief to be of real value for the education of sophomores in engineering. For many practical people who have the necessary background, it will provide a general introduction to some of these basic properties.

Since this is not a source book, it will not be of any great interest to the practicing metallurgical engineer. For those, however, who deal with the properties of metals and who desire a survey on some of the fundamental developments in this field, this book will be of interest.

The author has not always maintained care with respect to his definitions. For example, he discusses 'phases', but this reviewer has not been able to locate an adequate definition of 'phase' in the text that would be of real help to a sophomore in engineering. Reference is made to 'age hardening' but the mechanics of age hardening are not adequately discussed.

The reviewer's criticism of this book is not intended to discourage the use of the author's approach, but to draw attention to certain omissions in the text. One hopes that in the next edition the author will expand the material so as to improve the clarity. Professor Frankel's approach is worthy of study. The reviewer recommends that every teacher of engineering materials read this book and adopt some of the author's ideas in the presentation of their courses. Educators and practicing engineers can well afford to remember the apt statement made by Professor Frankel at the close of his book: "Not only will the student be called on soon to solve problems his teachers could not solve, but also he must be able to solve problems his teachers could not even imagine". Emphasis on basic principles will help to make this possible.

*Staff Report*

# *Fresh Look at Plating Problems*

**Improved surface preparation and specialized coatings can ease finishing troubles. Platers should shot-peen the steel prior to chromium plating if fatigue is a factor. Alloy plates, electroless nickel and hard anodizing are solving specific problems, according to facts revealed at the Electroplaters' meeting. (L17, L-general)**

SHOT-PEENING of steel before chromium plating should be used where fatigue is a factor. This is the opinion of workers in the materials laboratory at Wright Air Development Center. The recommendation is reflected in an amendment to Federal Specification QQ-C-320, requiring shot-peening prior to chromium plating for all applications where fatigue strength is considered important, Bennie Cohen of WADC told members of the American Electroplaters' Society at their annual meeting in Cincinnati recently.

The physical properties which make chromium electrodeposits excellent wear resistant coatings are the same ones which result in drastic reduction of the fatigue strength of the basis metal. Mr. Cohen attributed the lowering of fatigue strength principally to high residual tensile stresses in chromium plate. It is also generally known that this detrimental effect increases as the tensile strength or hardness of the steel increases. Detrimental hydrogen embrittlement of steel also increases as its tensile strength increases. This explains the need for baking after chromium plating.

Mr. Cohen stated that fatigue in steels can be separated into two classes: (*a*) high-stress, low-cycle fatigue; (*b*) low-stress, high-cycle fatigue. The effect of hydrogen embrittlement is predominant in high-stress, low-cycle fatigue and becomes most pronounced in static fatigue. The effect of chromium plating is most pronounced in low-stress, high-cycle fatigue or at the endurance limit.

### Details of Tests and Results

For the WADC study, fatigue specimens for the R. R. Moore type rotating beam machine were machined from ⅝-in. round bar stock of S.A.E. 4340 steel. One group was heat treated to Rockwell C-46 (220,000 psi.) and the other was heat treated to C-53 (280,000 psi.). All specimens were then finish machined and superpolished. One third of each group was set aside for control. Specimens were shot-peened according to Specification MIL-S-13165 A (Shot-Peening of Ferrous Metal Parts) by Aeroproducts, Allison Div., General Motors Corp., Vandalia, Ohio. A shot-peening intensity of 0.010 was used as determined by the Alman strip method given in the specification.

The test pieces were plated in a conventional chromium plating bath containing 33 oz. per gal. of chromic acid with $CrO_3$:$SO_4$ ratio of 100 to 1. Other plating details: current density, 2 amp. per sq.in.; time, 3 hr.; chromium thickness, 3.5 mils; bath temperature, 130° F. After plating, one half of each group was baked at 375° F. for 3 hr.

The following conclusions were drawn from these tests:

1. The chromium-plated, high-strength (280,000 psi.) steel specimens showed only a slight decrease in fatigue strength due to plating as compared with the drastic decrease (as much as 50%) obtained with steel specimens not shot-

*Fig. 1. – These Typical Die-Cast Parts Were Prepared for Plating Using a Loose Abrasive Finishing Machine. (Photo courtesy General Motors Corp.)*

peened before plating.

2. Shot-peening of medium-strength (220,000 psi.) steel actually increases the fatigue limit. Tests showed that shot-peened, chromium-plated specimens which were baked after plating had an endurance limit 18% higher than the unplated metal.

3. It should be recognized that high-strength steel has a higher resistance to plastic deformation than medium-strength steel when shot-peened with the same intensity. This means that the high-strength steel gets less cold work and has a thinner layer of residual compressive stress induced at the surface. A higher shot-peening intensity, which would give greater plastic deformation on the surface, would probably increase its effectiveness on high-strength steels. This suggests that a correlation exists between optimum shot-peening intensity and strength level.

4. Baking chromium-plated, shot-peened specimens at 375° F. for 3 hr. gives a slight increase in fatigue strength.

Further observations on how basis metal preparation affects the value of electroplates were reported by Maurice H. Jones, Ontario Research Foundation. He stated that corrosion tests made on Watts nickel deposits, 1 mil thick, showed that the method of polishing the steel basis metal affects the durability of the deposit. In general, a finer basis metal polish gives the coating better corrosion resistance. A commercial grease belt polish is superior to dry belt polishing, according to Mr. Jones's study. Corrosion tests employed were the acetic acid salt spray and Corrodokote method. Mr. Jones's investigation was sponsored by A. E. S. Research Project No. 14.

The high cost of hand buffing and polishing is spurring interest in mechanical methods for producing a high surface finish on parts prior to decorative plating. Fred T. Hall, General Motors Corp., told about the use of Gyrofinishing on various jobs at General Motors.

Equipment has been developed which employs dry, moist or wet slurry abrasive media in a loose condition. The method is effective for finishing decorative parts prior to plating and for deburring, burnishing, blending or edge radiusing machined parts. While different techniques are used in processing, each generally

*Fig. 2 – Section of Bushing Plated With Silver-Lead Alloy (1.5 to 3.0% Lead) Showing Cavitation Erosion Resulting From Engine Operation. The problem was solved by lowering the lead content of the deposit to the range 0.4 to 0.7% to take advantage of its complete solubility in silver. (Photo courtesy Curtiss-Wright Corp.)*

involves submerging the parts into a bulk abrasive mixture. By various arrangements of moving the parts through the abrasive, or by flowing the abrasive over the part, an efficient means of stock removal is achieved. Figure 1 shows die castings finished by this method prior to plating.

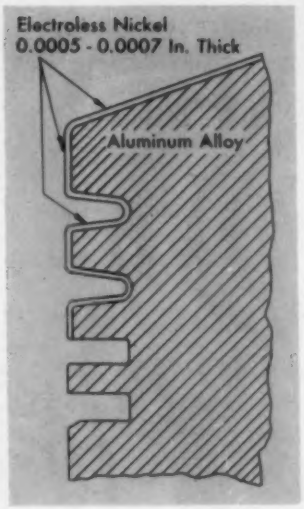



*Fig. 3 – Enlarged Cross Section of an Aluminum Piston Plated With Electroless Nickel. The catalytic reduction method gives an even deposit on all surfaces regardless of configuration. The nickel-phosphorus alloy produced is hardened by heat treating at 450° F. for 4 hr. (Photo courtesy Curtiss-Wright Corp.)*

### Cleaning and Pickling

Further emphasis on the importance of proper metal treatment prior to plating was made in a symposium on electroplating practices. William P. Innes, MacDermid Inc., Waterbury, Conn., pointed out that, in general, finishing operations, such as anodizing, chromating, phosphating, electro and chemical polishing, do not require the same high degree of cleanliness as needed for electroplating. Nevertheless, an active surface free from any interfering soil is required.

The degree of cleanliness required then depends on the process being performed. The wrong type of cleaning may be expensive as well as detrimental. For example, prolonged exposure to strong acid or alkali can contribute to excessive grain growth in phosphate coatings. Inadequate cleaning can also be expensive when the cost of rejected work due to poor cleaning is taken into consideration, Mr. Innes said.

Factors to be considered in the selection of a cleaning process, as given by Mr. Innes, are summarized as follows:

1. Basis metal – The cleaning medium must be compatible with the metal.

2. Soil – The type and condition of the soil determine whether precleaning is required. The cleaning medium to use may be determined from the knowledge of the soil and from previous experience with the same type of work. It may be best to run a few laboratory cleaning tests to arrive at the best medium and equipment. This should always be done in cases of doubt.

3. Water – The hardness of water to be used in the cleaning tanks should always receive attention, so that the cleaning materials are manufactured to handle the water hardness or the water is treated to remove hardness.

4. Equipment – Many cleaning jobs can be done in simple equipment. Today's high labor costs dictate that the equipment which will give the most economic operation be provided. It may be necessary (as is often the case) that the cleaning cycle be squeezed into existing equipment, which is inadequate for best results. In

*(Continued on p. 146)*

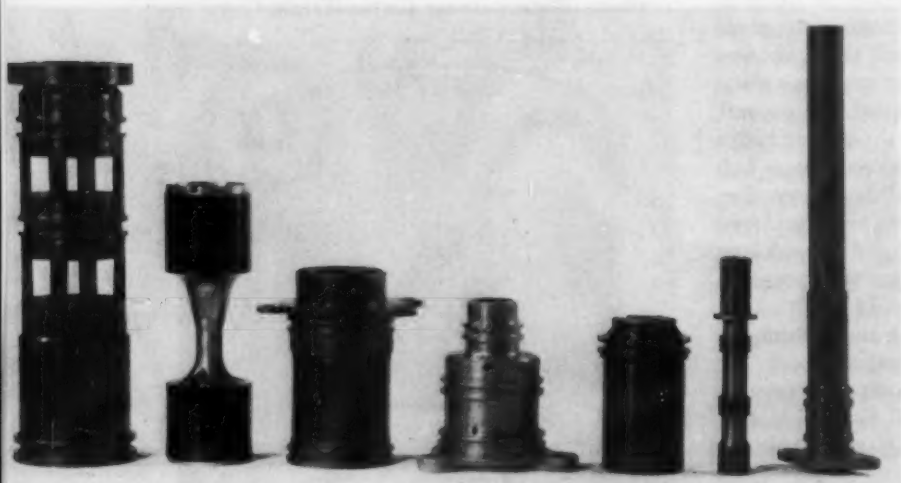
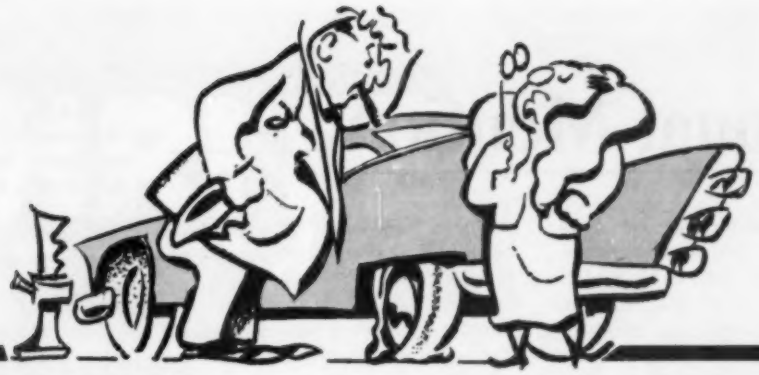


*Fig. 4 – These Fuel Metering Parts Have Been Given a Hard Anodized Finish for Improved Wear Resistance. Thin hard coat, heavy hard coat, and combinations of both can be produced on components to controlled thicknesses. (Photo courtesy Bendix Aviation Corp.)*

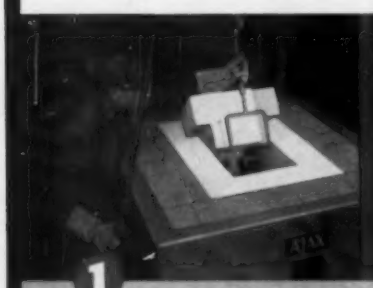


# CHANGE AJAX SALT BATH SUBMERGED ELECTRODES

## . . . almost as fast as you'd change a tire!

✓ in about an hour per pair ✓ often while the salt remains molten

✓ without tearing down either furnace or pot

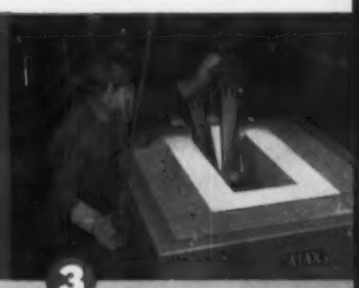


1

A closely fitted but readily removable tile block on top of the furnace seals the new Ajax removable submerged electrodes from air. Electrodes are exposed for easy replacement just by lifting the tile. No skilled labor is needed.

2

Electrodes enter furnace from the top and slant into the bath. There are no furnace openings whatever below the salt line. And there is no need to tear down any part of furnace or pot in changing electrodes!



3

Lift old electrodes out from the top . . . make replacements in about an hour per pair. In many cases, the job can be done while the salt bath remains molten, without even shutting the furnace down.

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No more lost production time when salt bath electrode changes are necessary! This revolutionary Ajax design development reduces the job to a matter of minutes . . . and reduces maintenance costs accordingly. Moreover, pot life is vastly increased because the pot is no longer torn down in the electrode changing process. Equally important, although Ajax Removable Submerged Electrodes are made of non-critical materials, their life materially exceeds that of nickel alloy electrodes of conventional design.

*Write for Ajax Bulletin 810*

*Associates: Ajax Engineering Corp., Ajax Electrothermic Corp.*

**AJAX HAS THE ANSWERS TO SALT BATH HEAT TREATING PROBLEMS!**

# Personal Mention

**Arnold L. Markey** has been promoted to general superintendent, Southwest Steel Rolling Mills, Los Angeles, Calif. He joined Southwest in 1955 following 20 years with the Joslyn Mfg. & Supply Co.'s stainless steel division at its Fort Wayne, Ind., plant.

**Charles E. Sallade**, recently discharged from the service, has returned to Frankford Arsenal, Philadelphia, where he is working as a physical metallurgist in the artillery ammunition division.

**Dennis S. Crowther** has left his position as senior experimental metallurgist in the engineering department, Electro-Motive Div., General Motors Corp., LaGrange, Ill., to accept the post of chief metallurgist in the engineering department of the Martin Co. of Orlando, Fla.

**Clay W. G. Fulcher** is studying toward a master's degree in mechanical engineering at the University of Texas. Concurrently, he is working part-time as research engineer with Defense Research Laboratory of the University of Texas.

**Herbert A. Robinson** has taken a position as senior research engineer at the Cities Service Research and Development Co. process research laboratory at Lakes Charles, La. He is in charge of the metallurgical investigations of the corrosion section.

**Ralph E. Anderson** is now a research metallurgist at Owens-Corning Fiberglas Corp., Toledo, Ohio, working with high-temperature alloys.

**Norbert L. Kopchinski**, formerly associated with the University of California Radiation Laboratory, Livermore, Calif., is currently acting as staff engineer, fuel elements and control rods, for Babcock & Wilcox Atomic Energy Div., Lynchburg, Va.

**D. C. Gray** has been transferred to Ft. Wayne, Ind., from St. Paul, Minn., as chief engineer of Crosby-Laughlin Div. of American Hoist and Derrick Co.

**Henry C. Ashley**, assistant metallurgical director at the Chase Metal Works of Chase Brass and Copper Co., Waterbury, Conn., for the past three years, has been named director of metallurgy.

**Leroy L. Wyman** received the Meritorious Service Award from the U. S. Dept. of Commerce for original contributions to alloy theory and to the design and production of important ordnance items. Chief of the chemical metallurgy section of the National Bureau of Standards, Mr. Wyman became a member of the NBS staff in 1953 and before that was associated with General Electric Co. for nearly 30 years.

**Frank S. Fitzgerald** has been appointed chief engineer of Adams Engineering Co., Inc., Miami, in charge of supervising and coordinating all engineering projects. An employee at Adams since 1956, he was formerly chief engineer of Carco Industries, Inc., Miami.

**Harold F. Wood, Jr.**, has announced the formation of the H. F. Wood Co., an industrial marketing firm with headquarters in Pittsburgh. Mr. Wood will serve as president while **Ward E. Duchene** will serve as vice-president and general sales manager and **H. F. Wood, Sr.**, will act as vice-president. The elder Mr. Wood, executive vice-president of Wyman-Gordon Co., will serve the new firm in an advisory capacity. Mr. Duchene was formerly manager of material handling at Heppenstall Co., Pittsburgh, and the younger Mr. Wood was manager of knife sales for that company.

**Thomas J. Schug** is now technical and personnel director of Carolina Personnel and Management Consultants, Charlotte, N. C.

**Martin J. Caserio**, formerly director of engineering, equipment sales and inspection for AC Spark Plug Div., General Motors Corp., Flint, Mich., was recently promoted to manager of the division's Milwaukee, Wis., operations.

**George A. Lennox** retired as vice-president, director of sales and member of the board of directors of the Driver-Harris Co., Harrison, N. Y., after 51 years of service. **Kenneth H. Hobbie** will assume the duties of vice-president and director of sales.

**John Szuhay** has been named sales engineer for the Pittsburgh area of the Steel and Tube Div., Timken Roller Bearing Co., Canton, Ohio. He became affiliated with the company in 1953 as a sales trainee and in 1954 was made sales engineer in the Cleveland district.

**Marcel A. Cordovi** has become a member of the staff of the atomic power development section, development and research division, International Nickel Co., New York. Prior to joining Inco, he was manager of the materials and testing department, atomic energy division, Babcock & Wilcox Co., New York. Since 1950 he has been a consultant in metallurgical engineering at Brookhaven National Laboratory and an adjunct professor of metallurgical engineering at the Polytechnic Institute of Brooklyn.

**L. A. Kristoff** has organized the Midwest Aluminum Supply Corp. with offices and warehouse in Cleveland, and will serve as president.

**Frank Bubsey**, formerly of American Blower Corp., Detroit, is now employed by the Peerless Electric Co. of Warren, Ohio.

**J. H. Hollomon** has been awarded the Rosenhain Medal for 1958 by the Institute of Metals, London. Dr. Hollomon, the first American to receive this award since its inception in 1950, was chosen on the basis of his contribution to scientific knowledge in the field of physical metallurgy. He is manager of the metallurgy and ceramics research Dept., General Electric Research Laboratory, Schenectady, N.Y.

**Harry W. Kole** has been appointed district sales manager of Kelite Corp., Berkeley Heights, N. J., covering Alabama, Florida, Georgia, North and South Carolina, and eastern Tennessee, with headquarters in Charlotte, N. C.

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CASTINGS FOR HIGH TEMPERATURE SERVICE

DESIGNED FOR LONGER SERVICE

Fahrite alloy castings for the heat treating industry give long, economical service. Careful design, metallurgical and foundry control techniques assure sound castings with high tensile strength and high resistance to thermal shock.

Our engineers need only complete details about the casting requirements of your heat treating operation to design and produce Fahrite castings with the correct characteristics to meet your exact operating conditions. A few of the many types of Fahrite castings made by Ohio Steel are:

| | |
|---|---|
| Rails | Rollers |
| Dipping Baskets | Radiant Tubes |
| Retorts | Fixtures |
| Solution Pots | Hearth Plates |
| Muffles | Chain |

Carburizing Boxes

THE OHIO STEEL FOUNDRY CO.

SPRINGFIELD, OHIO

Plants at Springfield and Lima, Ohio

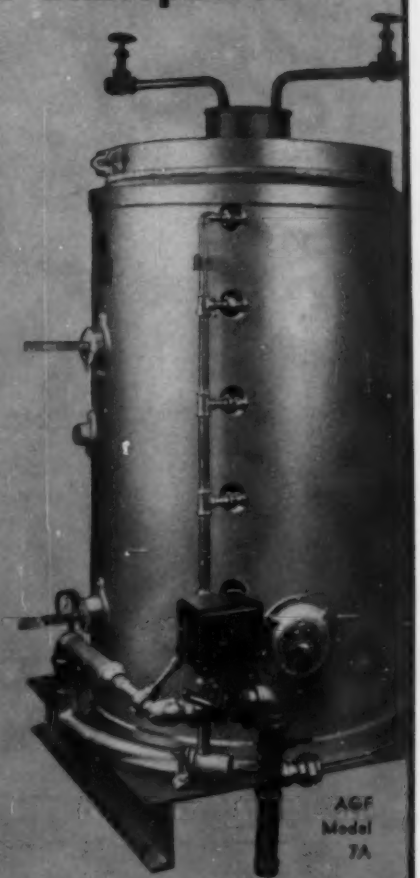
# AGF Gas Fired Ammonia Dissociators

## . . . for lowest cost hydrogen atmospheres

**Dissociated ammonia (75% $H_2$, 25% $N_2$) is the ideal atmosphere for the following processes—**

- Bright brazing and annealing of stainless steels.
- Bright hardening of certain stainless steels.
- Oxide reduction in metal powder production.
- Sintering of parts made from metal powders.
- Bright annealing of electrical components, thus achieving desired properties.
- A carrier for other atmosphere gases or combinations in special processes.

IN AGF BATCH AND CONTINUOUS PROCESS HYDROGEN ATMOSPHERE FURNACES



AGF Model 7A

**TROUBLE FREE**

Latest design gas fired combustion system provides continuous operating temperatures of 1850° to 1900° F. and is virtually trouble free. Amply sized operating components are designed to employ low ammonia vapor pressures thus eliminating the use of vaporizers or heat exchangers and permitting the safe use of higher operating temperatures.

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AMERICAN GAS FURNACE CO.

1002 LAFAYETTE STREET — ELIZABETH 4, N. J.

"Pioneers since 1878"


## Personals . . .

**William G. Slack** has been appointed superintendent of the bar finish and inspection department at Crucible Steel Co. of America's Sanderson-Halcomb Works in Syracuse, N. Y. **Joseph G. Eckert** was named to succeed Mr. Slack as superintendent of the conditioning and billet yard at the plant. Mr. Eckert was formerly general foreman of the hot finish products department.

**John J. Pikciunas, Jr.**, chairman of the Chattanooga Chapter, recently joined Combustion Engineering, Inc., Chattanooga, Tenn., as nondestructive testing engineer. Until accepting this new post, he was chief inspector of Cramet, Inc., in Chattanooga.

**Rolland R. La Pelle**, formerly manager of the industrial heating division of Westinghouse Electric Corp. on the West Coast, has accepted a position as manager of sales and engineering on aircraft, missile and special research furnace projects for Heat and Control, Inc., San Francisco. Westinghouse discontinued their nation-wide industrial furnace activity in March.

**J. F. Collins** is now serving the Electro Metallurgical Co., New York, as assistant manager of the Pittsburgh region. Mr. Collins joined Electromet in 1948 as research metallurgist in the Metals Research Laboratories in Niagara Falls, N. Y., and was transferred to the sales department in 1955.

**R. David Thomas, Jr.**, president of the Arcos Corp., Philadelphia, was awarded the Samuel Wylie Miller Memorial Medal by the American Welding Society for his contributions to the art of welding and cutting at the Society's annual meeting in St. Louis. Mr. Thomas was also elected vice-president of the Society.

**O. C. Miller** has been made district manager of the Buffalo, N. Y., sales office of the Steel and Tube Div., Timken Roller Bearing Co., Canton, Ohio, replacing **R. R. Hershey**. Mr. Miller joined the company in 1933 and has served in various cities throughout the country as metallurgical service representative. Since 1954 he had been a sales engineer in the steel sales division for the Chicago district.

1470 AB

# HANDIMET GRINDER

**A New, Wet Hand Grinder for Metallurgical Samples**

Now you may have wet grinding facilities for hand preparation in your laboratory at a nominal cost. Convenience at your fingertips, always clean and ready for use. Simply attach to water and drain facilities.

Individual elevated hard glass grinding surfaces are continually flushed with streams of water. This floats off the surface removal products, provides lubrication, and leaves sharp abrasive edges exposed at all times. A control valve permits complete selectivity of the volume of water. Ample drainage facilities with standard pipe fittings are provided at the rear. The grinding platforms are pitched downward and away from the operator.

The Handimet Grinding Paper is coated with a pressure sensitive adhesive backing and firmly holds when merely pressed against the flat grinding surface. It is easily removable when sheet is worn.

**No. 1470 AB HANDIMET GRINDER, complete $98.00**

**No. 1469-SW AB HANDIMET GRINDING PAPER for 1470 Grinder, Grits 240, 320, 400, 600 per 100....$10.00**

**No. 1469-1-SW AB HANDIMET GRINDING PAPER assorted 10 each grits 240, 320, 400, 600....$4.50**

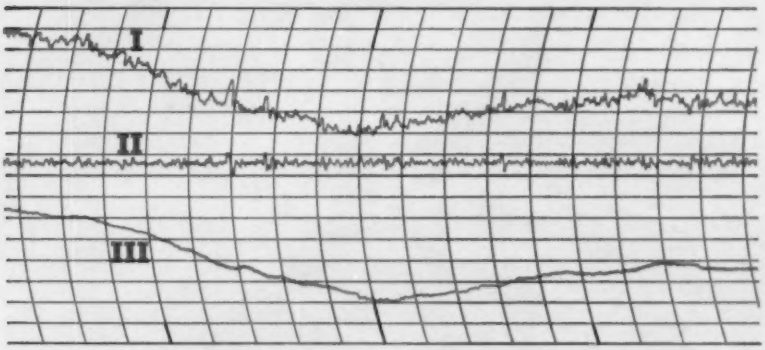
Buehler Ltd.

METALLURGICAL APPARATUS

**2120 GREENWOOD ST., EVANSTON, ILLINOIS, U.S.A.**

# PROFICORDER®

**PROVIDES SURFACE PROFILE RECORDS**

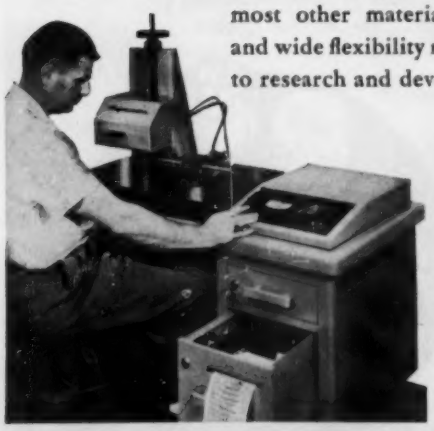



**Three Proficorder records of same portion of a surface, reproduced ½ size, showing (I) total profile, (II) roughness profile, and (III) waviness profile. Note range of detail.**

THE PROFICORDER draws a magnified profile of machined and finished surfaces, showing the *height, width* and *relative position* of the surface irregularities. It clearly shows any desired detail from over-all contour to fine roughness. Accordingly —

***These charts permit detailed study and comparison of waviness . . . roughness . . . porosity . . . flaws . . . wear . . . and the effects of finishing processes.***

The Proficorder will show (I) the total profile, (II) roughness alone, or (III) waviness, steps and other widely-spaced irregularities with roughness omitted. It is used on metals, paper, plastics, ceramics, and most other materials. Ease of operation and wide flexibility make it especially suited to research and development work.



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**BULLETIN LT24**

gives details. Write for it! And let us furnish you with profile charts of surfaces in which you are interested.

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Made by the Profilometer® people —

**MICROMETRICAL MANUFACTURING CO.**

359 S. MAIN ST. ANN ARBOR, MICHIGAN


## Personals . . .

**E. W. Schoen** has accepted the post of chief metallurgist for the Huck Mfg. Co., Detroit. For the past seven years, he was affiliated with the manufacturing engineering office, process development department, of the centrol staff of Ford Motor Co., Dearborn, Mich.

**Robert B. Oliver** recently accepted the position of manager of the New England Materials Laboratory, Medford, Mass. Prior to this appointment, he was on the staff of the metallurgy division of the Oak Ridge National Laboratory, working in high-temperature metallurgy and nondestructive test development.

**Gerald J. Horvitz** has been elected president of New York Testing Laboratories, Inc., New York. Mr. Horvitz was formerly technical director of the company.

**Peter C. Rossin** has been appointed technical director of the new Refractomet Div. recently established by Universal-Cyclops Steel Corp., Bridgeville, Pa. Before receiving this assignment, he was manager, pilot plant section, of the company's research and development department.

**Edward Skalka** has transferred from the Sanderson-Halcomb works of Crucible Steel Co. of America, Syracuse, N. Y., to the Cleveland branch of the company where he will act as vacuum metals specialist for the midwest region.

**Howard H. Heath** has accepted a position as project engineer with the Product Engineering Co., Portland, Ore. Prior to this appointment, he was chief engineer for Screw Machine Products Co., Portland, Ore.

**Robert L. Humphrey** has been appointed branch manager of the Grand Rapids, Mich., office of Kaiser Aluminum & Chemical Sales, Inc.

**Warren S. Peterson** has been named manager of the Aluminum Technical Center, a newly formed department at the metallurgical laboratories of Olin-Mathieson Chemical Corp. in New Haven, Conn. The new technical center will provide research and technical service to the aluminum division of the company and its customers.

*Interior of Kemp Melting Pot*

## For the inside story on low-cost melting pot operation . . .

# Come to Kemp

One 15 ton Kemp Immersion Melting Pot tempers 650 feet of steel strap a minute at Signode Steel Strapping Co., Sparrows Point, Md. High production schedules are maintained with substantial savings in fuel and down-time.

Kemp, the pioneer in immersion heating, can show you documented proof of the efficiency and economy of Kemp Immersion Heating Pots. For dipping, coating, and annealing in solutions, soft metals, and salts; Kemp units provide the precise control and economical operation that gives you a better product at lower cost.

Kemp Gas-Fired Immersion Heating Units put an end to cracked pots, costly heat losses . . . give you uniform heat distribution, quick recovery and high capacity. Kemp heating elements *inside* the pot transfer heat directly to the material being heated. There is no exposed flame, and radiation losses are minimized. You get accurate and sensitive temperature control, without overrun or lag.

Kemp pots are available in capacities from 1 to 75 tons, with melting rates up to 26 tons per hour. Your Kemp Representative will give you full details; or write us direct for Bulletin IE-11. The C. M. Kemp Mfg. Co., 405 East Oliver St., Baltimore 2, Md.

Kemp Convection Dryers

Kemp Inert Gas Generators

**KEMP OF BALTIMORE**

Kemp Industrial Carburetors

Kemp Oriad Dryers

# DISGUSTED WITH ABRASIVE CLAIMS?

A metallurgical analysis shows NATIONAL CONTROLLED ABRASIVES to have three fine qualities: (1) higher carbide content—it is the iron carbides that do the cutting—so you get better and faster cleaning action; (2) a ductile matrix—unique with NATIONAL CONTROLLED ABRASIVES—that is kind to your equipment and saves substantial sums on maintenance costs; and (3) lower phosphorus content—which indicates a resistance to breakdown—producing longer abrasive life.

These qualities are no accident, but the result of a carefully controlled melting process and the specially selected high quality steel scrap from which NATIONAL CONTROLLED ABRASIVES are made.

If your abrasive job calls for "chilled"—we'll beat the others hands down with ®CONTROLLED "T" by 25% to 40%. (And you can prove it simply with a Time Meter.) If your abrasive job calls for annealed or steel—we'll beat *both* with ®PERMABRASIVE by 10% to 20%!

**FREE**
EXPENDABLE PALLET PACK

Forty 50 lb. cartons in one master pack: easy to store, easy to inventory, easy and safe to handle. **No Extra Cost to you.** (Also in conventional 100 lb. or 50 lb. bags.)

**FREE**
TEST SAMPLE KIT

A free, no-obligation, lab analysis on your blastcleaning efficiency. See where your money goes. **No Cost to you.**

## USERS SAY

"Shot consumption records show . . . Conventional chilled iron shot at 27.8 lbs. per ton of castings cleaned . . . CONTROLLED "T" shot at 13.7 lbs."

"Quality Control Department reported 39 lbs. CONTROLLED "T" Grit per wheel-hour against 57 lbs. for the ordinary chilled used previously."

"A check of comparative costs shows that abrasive costs per wheel-hour with PERMABRASIVE are now almost exactly 20% less than with (blank) Steel Shot. Personnel most pleased with the finish received with PERMABRASIVE."

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3560 Norton Rd. • Cleveland 11, Ohio
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*Sole manufacturers of*
*®Permabrasive and ®Controlled "T" abrasives.*

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BRUMLEY-DONALDSON COMPANY
Los Angeles · Oakland

***Write Department 8-C***


## Personals . . .

**W. C. Webster**, a recent graduate of Rensselaer Polytechnic Institute, is now employed in the process development section of General Motors Technical Center, Detroit, as a junior welding engineer.

**William K. Neff** has been transferred to St. Louis, Mo., as a toolsteel sales engineer covering southern Missouri and Arkansas for Allegheny Ludlum Steel Corp., Pittsburgh. For the past four years, he was assigned to the company's Carmet Div. in Philadelphia.

**Robert Teeg** recently completed the requirements for a doctorate in metallurgy at Massachusetts Institute of Technology, and is now associated with M. & C. Nuclear, Inc., Attleboro, Mass., as assistant department head in the research and development department.

**William L. Harbrecht** has retired after 38 years in research development work with the Electro Metallurgical Co., Niagara Falls, N. Y. Mr. Harbrecht, a past chairman of the Buffalo Chapter, will continue to be active in the metallurgical field as a consultant.

**Harry W. Dietert**, chairman of the board, Harry W. Dietert Co., Detroit, was elected president of the American Foundrymen's Society at the AFS Castings Congress and Show in Cleveland. At the same time, **Charles E. Nelson**, was elected vice-president of the Society; he is technical director of the magnesium division of Dow Chemical Co., Midland, Mich. New directors of the Society include: **David W. Boyd**, vice-president and general manager of Engineering Castings, Inc., Marshall, Mich.; **Thomas W. Curry**, director of research, Lynchburg Foundry Co., Lynchburg, Va.; and **Jake Dee**, Dee Brass Foundry, Inc., Houston, Tex.

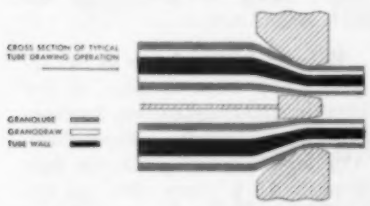
**Howard Brooks**, formerly of Krouse Testing Machine, Inc., Columbus, Ohio, is now with the State Highway Labs.

**Michael Zajac** has been named to the newly created position of vice-president in charge of engineering at Buhr Machine Tool Co., Ann Arbor, Mich. He assumed this position after 2½ years as chief engineer.

# CHEMICAL CONVERSION COATINGS and their functions in facilitating the cold mechanical deformation of metals

By ARTHUR DAHL, Product Development Dept., Amchem Products, Inc.

When used to facilitate the cold mechanical deformation of metals (in drawing, extrusion, stamping, cold heading, necking, and upsetting operations) chemical conversion coatings in conjunction with suitable lubricants perform three important functions. One, they prevent metal-to-metal contact between work and tool. Two, they prevent galling and seizing. Three, they protect stock indefinitely, permitting the storage of in-process work at any stage of production, without danger of corrosion damage.




Characteristic of the tightly bound, highly absorptive, crystalline coating formed by the processes is the ability of the coating to retain lubricity throughout forming operations when treated with a suitable lubricant. This offers the following production advantages:

- **Higher degree of reduction**
- **Greater speed of draw**
- **Longer tool life**
- **Fewer process anneals and pickling**
- **Finer surface finish**
- **Cleaner mills**
- **Easier inspection of finished product**

Also of interest to production men is the exact duplication of coatings from batch to batch. And the processes are much simpler than other methods of coating metals—baths can be set up and running in less time than it takes to determine suitable coatings by other methods.

## TYPES OF COATINGS AND THE METALS FOR WHICH THEY ARE DESIGNED

**Zinc phosphate coatings for carbon steel.** These coatings can be applied by either dip or spray systems.

**Dip.** ACP Granodraw No. 1 is typical of the dip process. The sequence includes precleaning, water rinse, pickling, water rinse, water rinse, Granodraw No. 1 solution, water rinse, and a hot neutralizing rinse. Surfaces to be treated must be free of oil, grease, rust and scale. The above sequence insures that they will be. And when metal is free of rust and scale, the pickling bath and two succeeding water rinses can be omitted. In either case, a lubricant like ACP Granolube or conventional lubricant must be applied prior to working the metal.

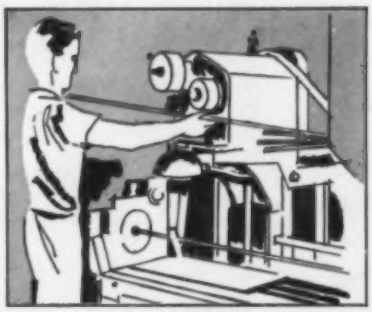
**Spray.** ACP Granodraw No. 4 is an example of the spray process. It usually requires 5-stage equipment and includes the following steps: precleaning, water rinse, Granodraw No. 4 solution, water rinse, lubricant. After chemical treatment, the work must be dried before forming.

**Oxalate Coatings for the stainless steels and many of the high nickel alloys.** These coatings are applied only by immersion process, and usually in a 5-stage system which includes an acid pickling or depassivating bath, a water rinse, the ACP Granodraw SS coating bath, a hot borax neutralizing rinse for wire stock, or a lubricating bath for tube stock. Since thorough activation of the metal surface is necessary to promote an adherent coating, the pickling and activating bath is an important stage in processing.

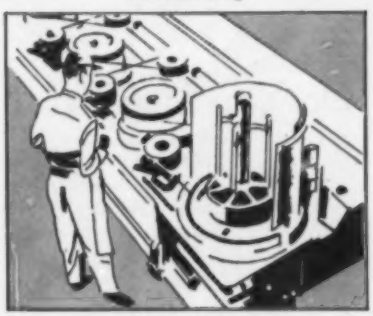
**Fluoride-type coatings for zirconium and its alloys.** Granodraw ZR is such a coating. It is applied in an immersion process which includes precleaning, water rinse, pickling, water rinse, Granodraw ZR solution, water rinse, drying or lubricating. It has been used primarily in the treatment of stock prior to wire drawing and tube drawing. Surfaces are cleaned of oil and grease by solvent degreasing or alkali cleaning. Pickling is required to provide a surface that is chemically and metallurgically receptive to the coating.

**Strong alkali coatings for tantalum and amorphous phosphate coatings for aluminum.** These two types of coatings are now in the development stage. Laboratory and field tests are being conducted, results are being evaluated, and modifications in chemical makeup and process sequence are being made to meet requirements. Several field tests, however, have indicated that they will do the same job for tantalum and aluminum processors as the other types of coatings have done for those working carbon steel, stainless steel, high-nickel alloy, and zirconium.

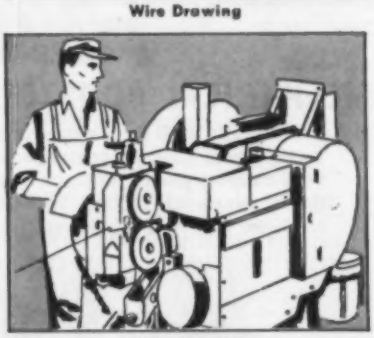
*For more information write us at Ambler.*



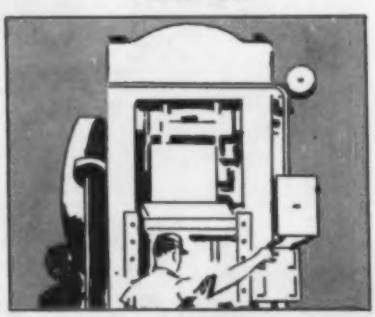
Tube Drawing



Wire Drawing



Cold Heading



Impact Extrusion

Note. Granodraw and Granolube are registered trademarks of American Chemical Paint Company.

**Amchem Products, Inc. Ambler 16, Pa.**

Formerly AMERICAN CHEMICAL PAINT COMPANY

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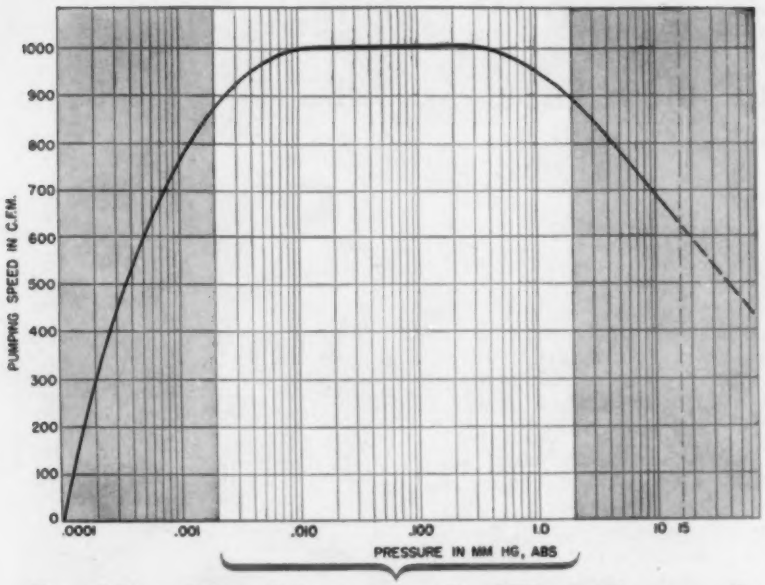
*New Chemical Horizons for Industry and Agriculture*



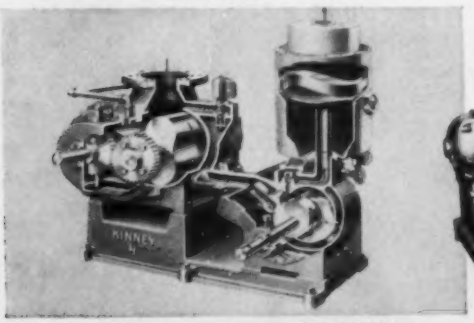

## Do You Use Vacuum In This Range?

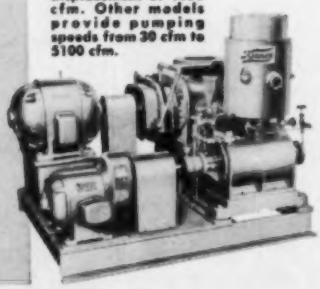
From millimeters to microns . . . in this region the significant economy of the KINNEY KMB Mechanical Booster Pump is self-evident, as shown by the performance curve above. And, this high efficiency is doubly attractive because these KINNEY Pumps provide *clean, dry* Vacuum . . . no backstreaming . . . automatic operation . . . no stalling problems from gas bursts.

Kinney®

## MECHANICAL BOOSTER HIGH VACUUM PUMPS

The KINNEY KMB Pumps have proven themselves in the most difficult applications. Their performance, even where outgassing of materials renders other pumps inoperative, stamps them as the major contribution of the decade in High Vacuum service. Models range from 30 to 5100 cfm free air displacement.





KMB 1200 with free air displacement of 1230 cfm. Other models provide pumping speeds from 30 cfm to 5100 cfm.

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3584G WASHINGTON STREET • BOSTON 30 • MASS.

Please send me copy of Bulletin No. 400A describing KINNEY KMB High Vacuum Pumps.

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Company_____

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## Personals . . .

**W. R. Clough** recently resigned as section leader, tantalum and columbium research section, Metals Research Laboratories, Electro Metallurgical Co., Niagara Falls, N. Y., to become supervisor of metals research and development Connecticut Aircraft Nuclear Engine Laboratory, Pratt & Whitney Div., United Aircraft Corp., Middletown, Conn.

**Bertram M. Mullin**, a graduate of Massachusetts Institute of Technology and the General Electric Chem-Met Training Program, is now studying law in Washington, D. C. and working concurrently for the U. S. Patent Office.

**Edmund J. Wheelahan** has accepted a position as head of the physical metallurgy section, Southern Research Institute, Birmingham, Ala., after requesting inactive duty from the U. S. Navy. He was formerly director of the Aeronautical Materials Laboratory, Philadelphia.

**T. R. Bergstrom**, after his release from the Civil Engineers Corp., U. S. Navy, last December, accepted a position as an associate research engineer with the Boeing Airplane Co., Seattle, Wash.

**Donald A. Donner** is currently employed as assistant planning supervisor, Hunter Engineering Co., Riverside, Calif.

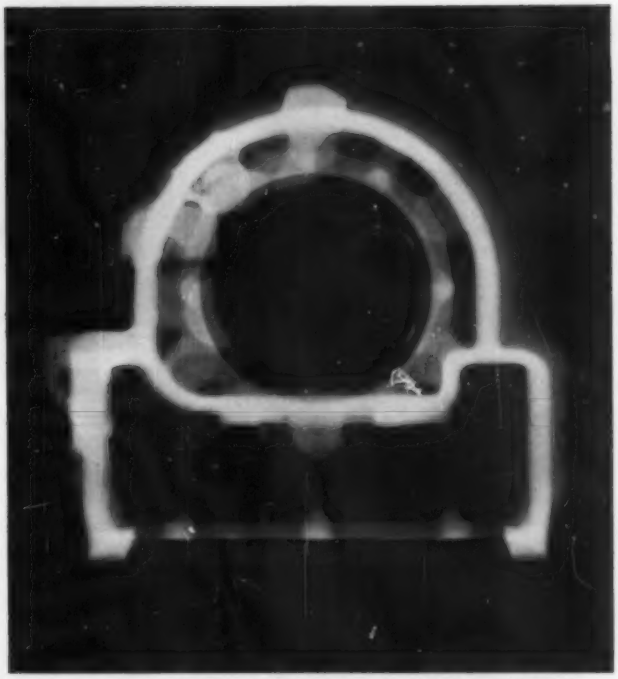
**Willard H. Hawley** has been assigned to the Ordnance Materials Research Office, Watertown Arsenal, Watertown, Mass., as metallurgist. He formerly held a similar position with the Bureau of Ships, Navy Dept., Washington, D. C.

**Kenneth V. Ludlum** has been named manager of the Thermix Corp.'s newly formed subsidiary, Thermix Florida, Inc., West Palm Beach. Mr. Ludlum was a senior sales engineer with the export division of Curtiss-Wright Corp., New York, before accepting his new assignment.

**I. C. Sleight**, formerly manager, quality control division, Aerojet-General Corp., Azusa, Calif., has accepted a new assignment as manager, quality control division, of the company's solid rocket plant in Sacramento, Calif.

Shrink caused leakage...

# Radiography showed how to correct it



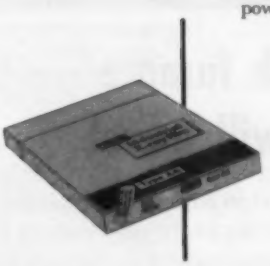
Radiograph of rough casting for air turbine-driven power supply gear housing.

This casting is the gear housing of a vital air turbine-driven power supply produced for the Utica Division of Bendix Aviation Corp. for use in jet-age aircraft. It must operate at temperatures up to 300°F with utmost dependability.

Seepage of oil through the shell was a recurring problem. And this is where radiography came in with a double-barreled assist. First, radiographic examination of the rough castings provided information to help determine whether the castings would prove acceptable when machined — *before* more than 150 machining operations were performed. Second, the radiographs revealed the cause of the difficulty—internal shrinkage—and disclosed a recurring pattern which led to placing chills so as to overcome it.

Result: a critical part became a routine production item with substantial savings in time and costs to both foundry and manufacturer.

If you would like to know how radiography can improve your own operations, talk it over with your x-ray dealer—or the Kodak technical representative.



## The new Kodak Industrial X-ray Film, Type AA, gives you these advantages

- Reduces exposure time—speeds up routine examinations.
- Provides increased radiographic sensitivity through higher densities with established exposure and processing technics.
- Gives greater subject contrast, more detail and easier readability when established exposure times are used with reduced kilovoltage.
- Shortens processing cycle with existing exposure technics.
- Reduces the possibility of pressure desensitization under the usual shop conditions of use.

Kodak Industrial X-ray Film, Type AA, is now available with or without interleaving paper, as you may desire.

**EASTMAN KODAK COMPANY**
**X-ray Division · Rochester 4, N. Y.**

Kodak

Built by
HEVI-DUTY
specialists in
electric furnaces

# Versatile salt bath furnace has extra pot...will travel

Versatility and portability are the chief advantages of this immersed electrode Hevi-Duty salt bath furnace at Clevite Research Center in Cleveland. Since work here is experimental, the furnace must be used on a wide variety of operations. It is equipped with a welded steel pot for low-temperature heat treating and an interchangeable ceramic pot for temperatures up to 2300° F.

The furnace is coupled with a transformer and mounted on rollers so that it may be used anywhere in the shop.

Perhaps this combination of adaptability and portability can fit into your operation — and save you the cost of two or more specialized furnaces.

Write for Bulletin 655 for further information about Hevi-Duty salt bath furnaces, or outline your particular problem.

- Heat Processing Furnaces
- Dry Type Transformers
- Constant Current Regulators

HEVI-DUTY
ELECTRIC CO.
Milwaukee 1, Wisconsin

## Personals . . .

**David H. Fenton**, recently discharged from the U. S. Navy, has rejoined Reynolds Metals Co., Richmond, Va., as a project engineer in the engineering development group.

**J. William A. Tyler** has joined the Houston, Tex., plant of Sheffield Div., Armco Steel Corp., as product metallurgist, following his discharge from the U. S. Air Force.

**Kurt W. Dollansky** has left the department for research and development of the Canadian National Railway, Montreal, Que., to organize and take charge of a new metallurgical department for Combustion Engineering-Superheater, Ltd., Sherbrooke, Que.

**William C. Hagel** has been transferred from the Large Steam Turbine-Generator Dept., General Electric Co., in Schenectady, N. Y., to the position of manager, metallurgical development, in the measurements laboratory at the Instrument Dept. of the company in West Lynn, Mass.

**Glen Krouse** is now vice-president of Tatnall Measuring Systems Co., Philadelphia, a subsidiary of the Budd Co.

**W. R. Schick** has graduated from Ohio State University and is now assistant chief metallurgist in the laboratory of the Ohio Injector Co., Wadsworth, Ohio.

**N. H. Polakowski** has been promoted to the rank of full professor of the Illinois Institute of Technology. Before joining the faculty of Illinois Tech, he was development manager of the Armzen Co. and consulting engineer at LaSalle Steel Co.

**John Winters** has been promoted to sales engineer in the Chicago sales office of the Steel and Tube Div., Timken Roller Bearing Co., Canton, Ohio, replacing **O. C. Miller**. Mr. Winters came to Timken in 1956 and just recently completed the sales trainee course.

**Roger Waindle**, president of WaiMet Alloys Co., a division of Consolidated Foundries and Mfg. Corp., Detroit, represented the Investment Castings Institute at the European Investment Casting Assoc. meeting in Paris, France.

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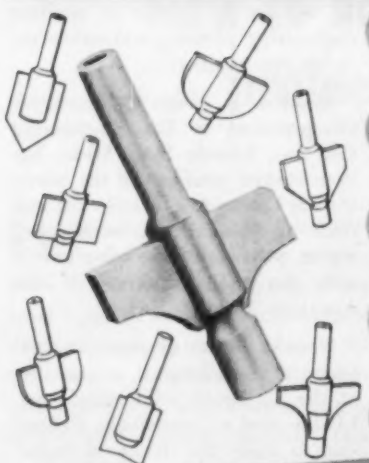

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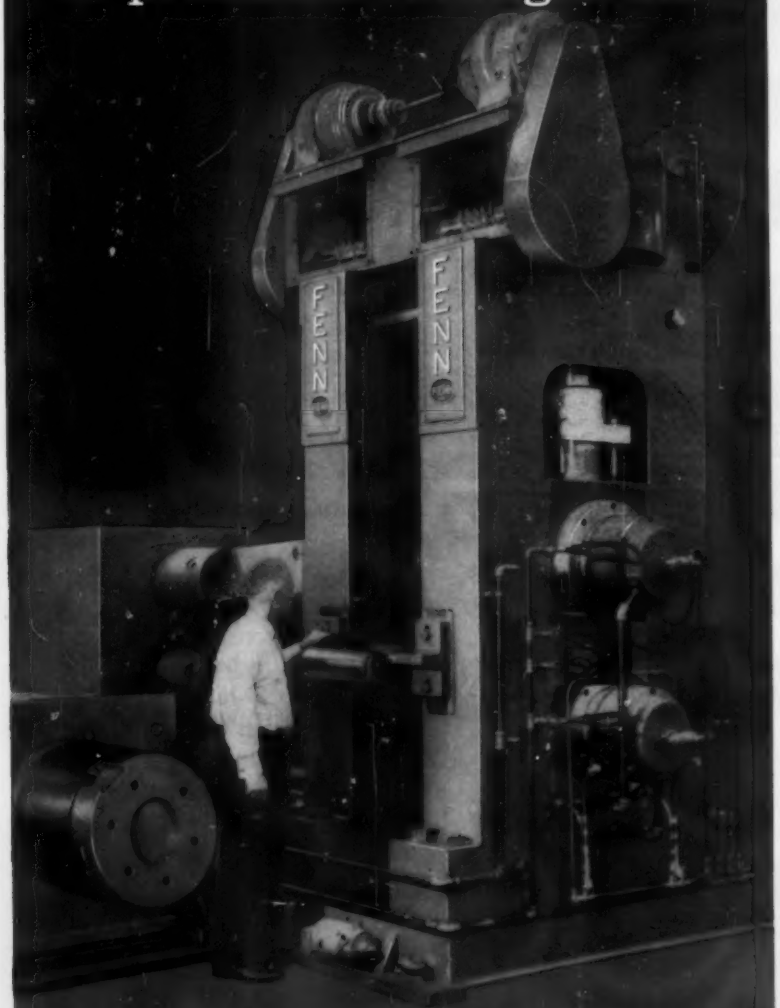


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## Personals . . .

**Alfred Hoagland** has been promoted to supervisor, service metallurgy, railroad materials and forgings, for U. S. Steel Corp. in Chicago. He joined U. S. Steel in 1937 at the Homestead, Pa., works, and was service metallurgist at the Pittsburgh office until his promotion.

**R. R. Hershey** has assumed new duties as district manager of the Cincinnati, Ohio, office of the Steel and Tube Div., Timken Roller Bearing Co., Canton, Ohio. He joined Timken in 1940 and has served in the Cleveland, Milwaukee and Buffalo sales office, most recently acting as district manager in Buffalo.

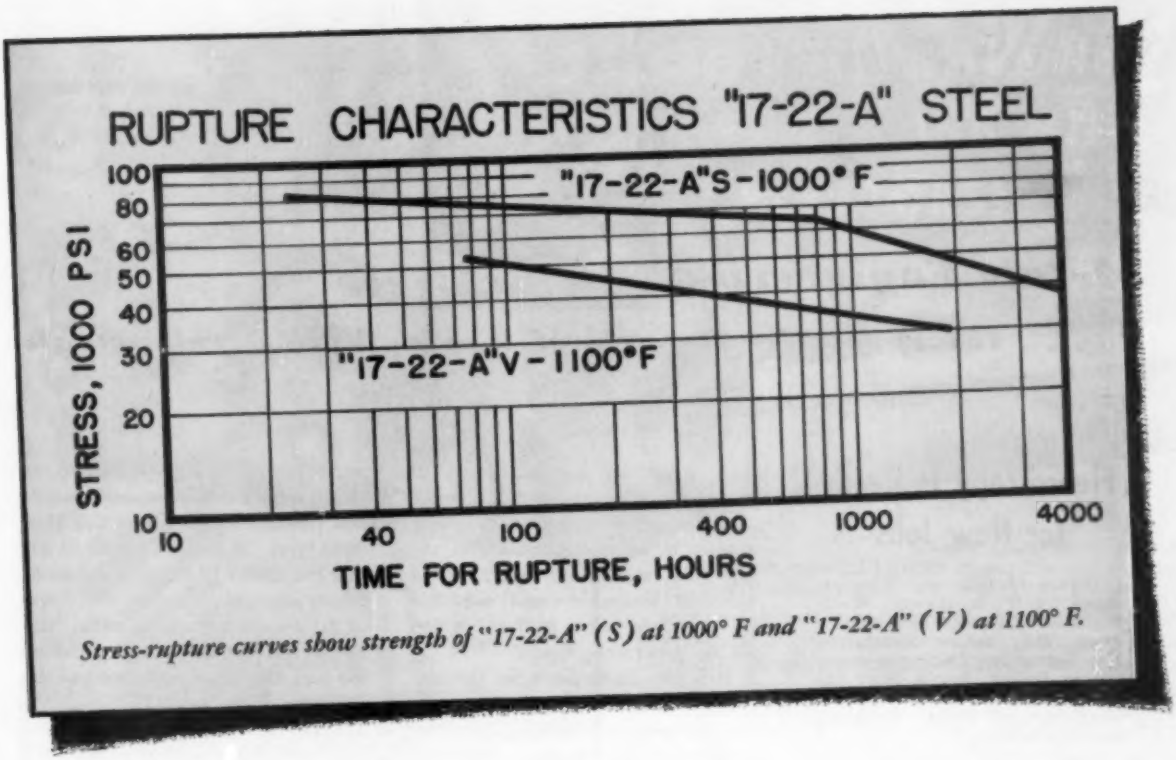
**J. J. McGrann** has been named district manager of the Los Angeles office of the Steel and Tube Div., Timken Roller Bearing Co., Canton, Ohio. He started with Timken as a sales engineer in the home office and last served as district manager of the Cincinnati, Ohio, office.

**Joseph A. Harinek** has been appointed chief engineer of the Gibson Div., Associated Spring Corp., in Chicago. Formerly plant manager, he will be in charge of product engineering, planning and estimating in his new position.

**Knowles B. Smith**, executive vice-president of Dix Engineering Co., Inc., Lincoln Park, Mich., has been elected president of the Metco System Contractors, a technical and trade organization, at its recent meeting in St. Louis, held concurrently with the annual meeting of the American Welding Society.

**Norman Brown**, associate professor of metallurgical engineering at the University of Pennsylvania, has received a Guggenheim Fellowship to study the theory of imperfection in solids. During his year's leave of absence he will carry out research at the Cavendish Laboratory, Cambridge University, England; this summer he will be studying at the Max Planck Institute in Stuttgart, Germany.

**Wesley G. Nilson** has concluded an assignment at the Atomic Energy of Canada Ltd., Chalk River, Ont., and has returned to the research laboratory of the International Nickel Co., Inc., at Bayonne, N. J.




*Stress-rupture curves show strength of "17-22-A" (S) at 1000° F and "17-22-A" (V) at 1100° F.*

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# Fluoroscopy Is Ready for New Jobs

Digest of talk on "Fluoroscopy" by W. R. Hampe, Westinghouse Electric Corp., Baltimore, Md., before Society of Nondestructive Testing at meeting in Dallas, Texas, May 11-16, held in conjunction with Southwestern Metal Congress and Exposition.

FLUOROSCOPY is invading a number of industries as a successful testing technique. It meets the requirements of modern production for a low cost, nonrecording, high volume, accurate means of internal inspection. Improvements in technique have increased its uses in applications previously limited to less desirable methods.

One of the limiting factors in the early industrial uses of fluoroscopy was its comparatively poor sensitivity. Sensitivity may be defined as the measure of success in detecting variations from a standard. It is customary to express sensitivity as the per cent ratio of the dimension of the least detectable variation to that of the whole, taken in the direction of the penetrating beam.

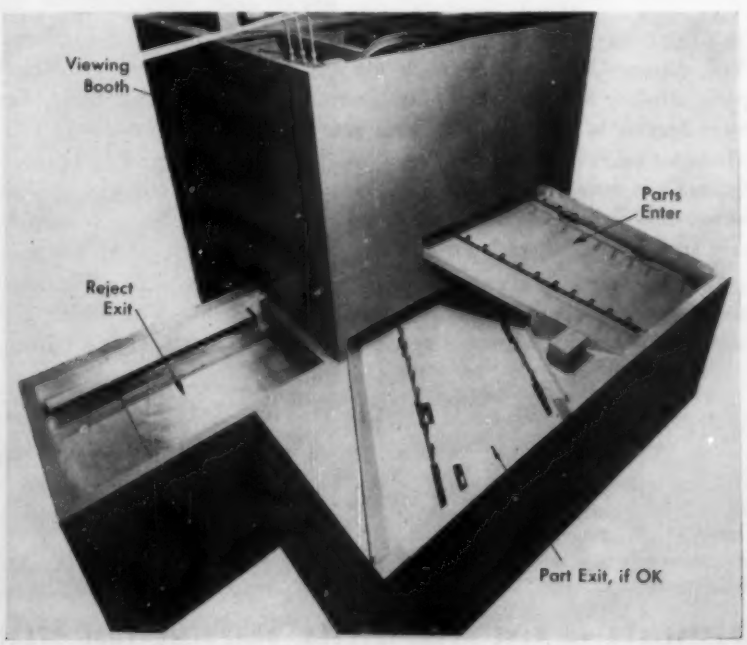
It is difficult to point out the sensitivity limitations of any of the modern fluoroscopic techniques in terms of flaws or discontinuities, expressed as a percentage of the base material, for all applications. Therefore, as in radiography, the sensitivity of the technique is usually described as penetrameter sensitivity, using a typical penetrameter such as the MIL 6865 type. It should be pointed out that the ability to perceive a discontinuity also depends upon the shape of the discontinuity, its position relative to the central beam, its location, the part, the subject contrast and the thickness of the part.

**Types of Flaws** – In metals, discontinuity takes several forms with various degrees of severity:

1. Linear discontinuities – tears or cracks (hot or cold).
2. Shrinkage-cavity type, sponge microshrinkage or a combination.
3. Inclusions, lighter or heavier density than the parent substance, which may occur in a linear fashion, in a group, or well distributed.

*Fig. 1 – Standard Fluoroscope With Inspector in Viewing Booth*

*Fig. 2 – A Completely Mechanized Fluoroscope for Simultaneously Examining Both Ends of a Tube, 3 In. in Diameter by 30 In. Long. Unit will handle 20 tubes a minute with two inspectors*



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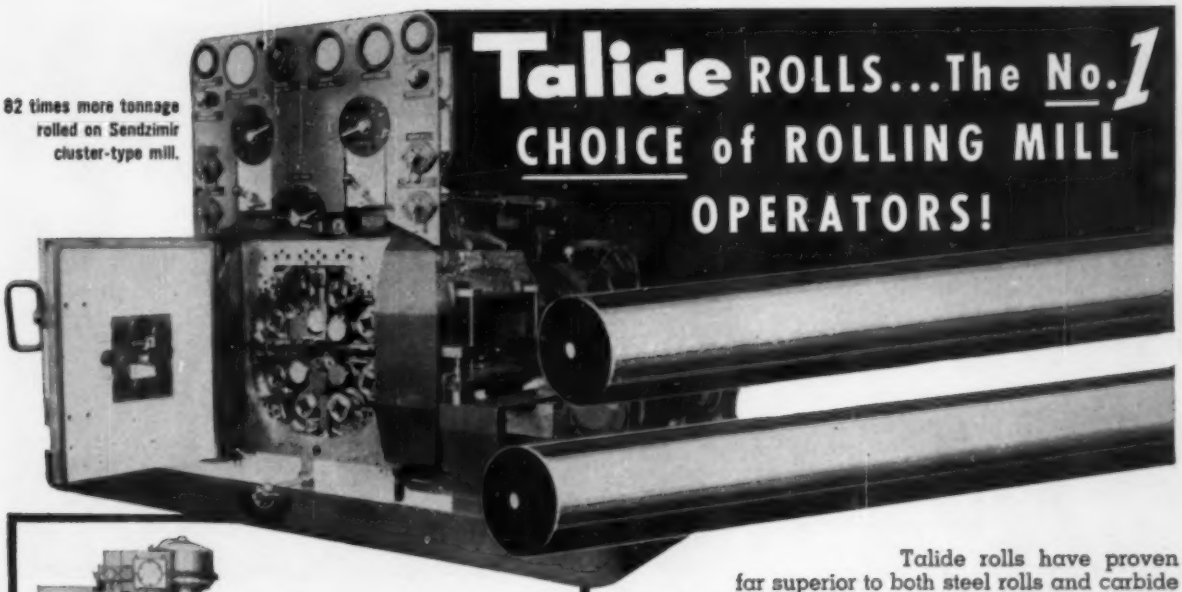
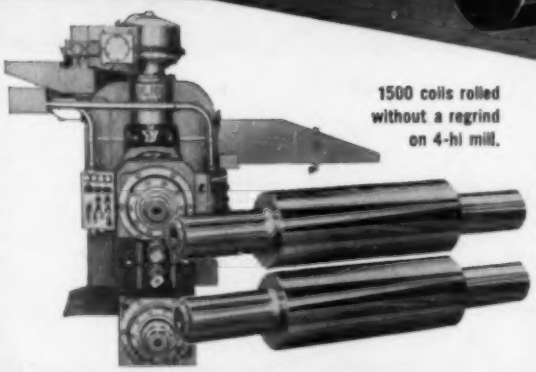
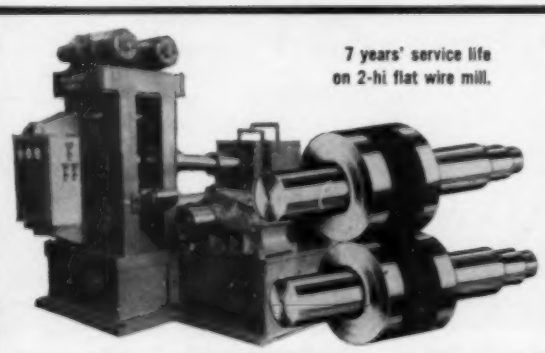


82 times more tonnage rolled on Sendzimir cluster-type mill.



1500 coils rolled without a regrind on 4-hi mill.



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Talide work rolls are ultra-hard, extremely dense and porous-free. Manufactured from highest purity tungsten carbide powders, the surface finish of a Talide roll is smoother than one micro-inch. Hard as a diamond, it will take a "bigger bite" than a steel roll. Strip steel of all analyses can be rolled down to thinner gauge, with more accuracy, greater reductions and with fewer anneals than possible with any other roll.

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- ★ LONGER LIFE
- ★ HIGHER SPEEDS
- ★ CLOSER TOLERANCE
- ★ IMPROVED PHYSICALS
- ★ GREATER REDUCTION
- ★ LESS DOWN TIME
- ★ FEWER REJECTS
- ★ LESS MAINTENANCE

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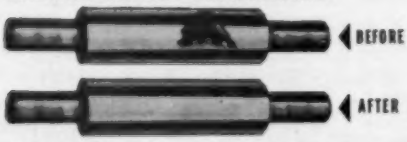


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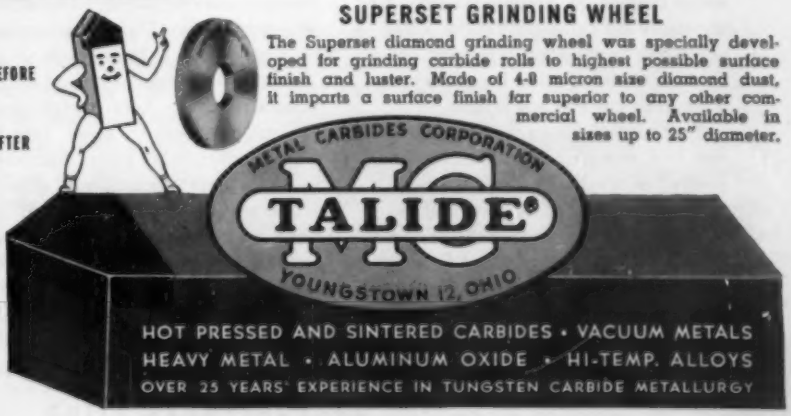
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4. Porosity – round or elongated areas which may be scattered at random.

In welds, all of the above discontinuities are found, plus defects such as incomplete penetration or lack of fusion, and such artifacts as undercutting and splatter.

Fluoroscopy is particularly successful in locating linear discontinuities. The advantage that the inspector has control of the motions of the part permits him to receive an image of it from a variety of directions depending upon its contours and dimensions. Shrinkage may be seen readily if it is of the cavity type or of the coarse sponge variety. Microshinkage is difficult to see.

If the inclusion has a preferred geometry which is hard to detect radiographically, fluoroscopy may do the trick. In rocket powder inspection, high-definition fluoroscopy has proved to be more satisfactory than radiography in locating certain metallic inclusions.

For those who have been unsuccessful in using fluoroscopy as an inspection test, a close look should be taken at the following possible reasons for difficulty:

1. The inspector may have no previous experience in reading radiographs. Experience is needed to accustom oneself to the reversal of image densities.

2. Techniques – Many existing fluoroscopes are of the conventional type which can only be used for fairly gross details.

3. Eye Accommodation – The degree of eye accommodation grows less as the technique involved moves from conventional to the high definition type. With image amplifiers some degree of accommodation is necessary for optimum results. The amplifiers now permit television projection to bring the image up to where the eye can see it best.

4. Personal Characteristics – The eye is a complex mechanism when acuity depends on age, fatigue, amount of correction, sex and accommodation. There are other factors such as general physical fatigue, and ambient conditions which affect perception.

5. Experience in Dynamic Viewing – While a radiograph is a single interior image of an object, fluoroscopy permits multiple views of the object which change continuously as the part is moved. It may take a long training period to educate the inspector in the technique.

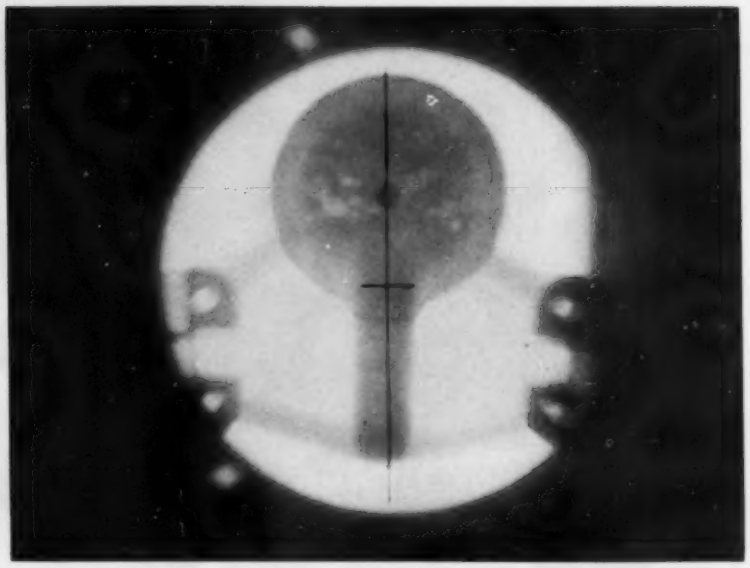

*Fig. 3 – A Fluoroscopic Image Showing Porosity*

Three basic fluoroscopic geometric arrangements are used in industry today – conventional, high-brightness and high-definition. Components may consist of a variety of generators, image-forming devices and materials handling schemes.

**Conventional** – This technique is generally employed for the detection of gross differences in thickness and density:

Tubes: 100 to 150 kvp.
Targets: 1.5 to 2.3 mm.
Screen: Patterson B2 – Radelin FG.
Target-screen distance: 15 to 24 in.
Specimen location: As close to the screen as possible.
Protection: Lead oxide glass.
Penetrameter sensitivity: 7 to 13%.
Practical limits: 1¼ in. aluminum, 2 in. magnesium, 1/16 in. steel.

*Advantages:* Simplicity, low cost.

*Disadvantages:* Low brightness (low visual acuity); large target (poor detail); lead glass discolors (decreases light transmission which must be restored by heating). It is difficult to place the specimen in a proper relationship to the screen, particularly on a production basis.

One commercial application of this method is the examination of brazed parts for gross discontinuities in the brazed area.

**High-Brightness** – This technique is recommended for the detection of moderately large differences in thickness or density:

Tube: 100 to 150 kvp.
Targets: 1.5 to 2.3 mm.
Screen: Patterson B2, or Radelin PG.
Target-screen distance: 5 to 12 in.
Specimen location: As close to the screen as possible.
Protection: Protective cell using chemical solutions or heavy thickness of lead oxide glass.
Practical limits: 2 in. aluminum, 3 in. magnesium, ⅛ in. steel.
Penetrameter Sensitivity: 6 to 11%.

*Advantages:* High brightness (better visual acuity); pseudorotational effect (more chance of discovering defects requiring preferred orientation of beam); no long-time dark adaption required; slight magnification of image.

*Disadvantages:* Increased unsharpness of image of objects not close to the screen; limited field size; some chemical solutions are unstable in the dry state, other chemicals discolor, requiring infrequent clearing operations; lead glass discolors rapidly; there is difficulty in placing the specimen in proper relationship to the screen, particularly in production.

Uses of the high-brightness method are similar to those in conventional fluoroscopy but it is applied to heavier parts and it is used for finer detail. The 250-kv., constant-

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## Fluoroscopy . . .

potential, X-ray generator using a 3.5-mm. target tube has been used experimentally for thicker or more dense parts with conventional and high-brightness techniques. Sensitivity obtained routinely is estimated to be 8 to 14%. The approximate limit appears to be above ½ in. steel. The image has been mirror viewed for the operator's safety. Direct viewing through a suitable protective window would improve sensitivity and increase the possible thickness limit. One laboratory reports that steel 1½ in. thick can be inspected with about 6% sensitivity.

**High-Definition** – This technique is used for detection of small differences in thickness and density:

Tube: 150 kv.

Target: 1 mm. maximum.

Screen: Radelin F.

Target-screen distance: 12-18 in.

Specimen location: At the point between the screen and the X-ray target which will give the optimum magnification of the image consistent with the focal-spot employed and the inherent screen unsharpness for the discernment of the minimum observable defect. For a focal spot of 1 mm. with Radelin F screen, the optimum magnification is about 2.

Protection: Lead silicate glass.

Penetrameter sensitivity: 2%.

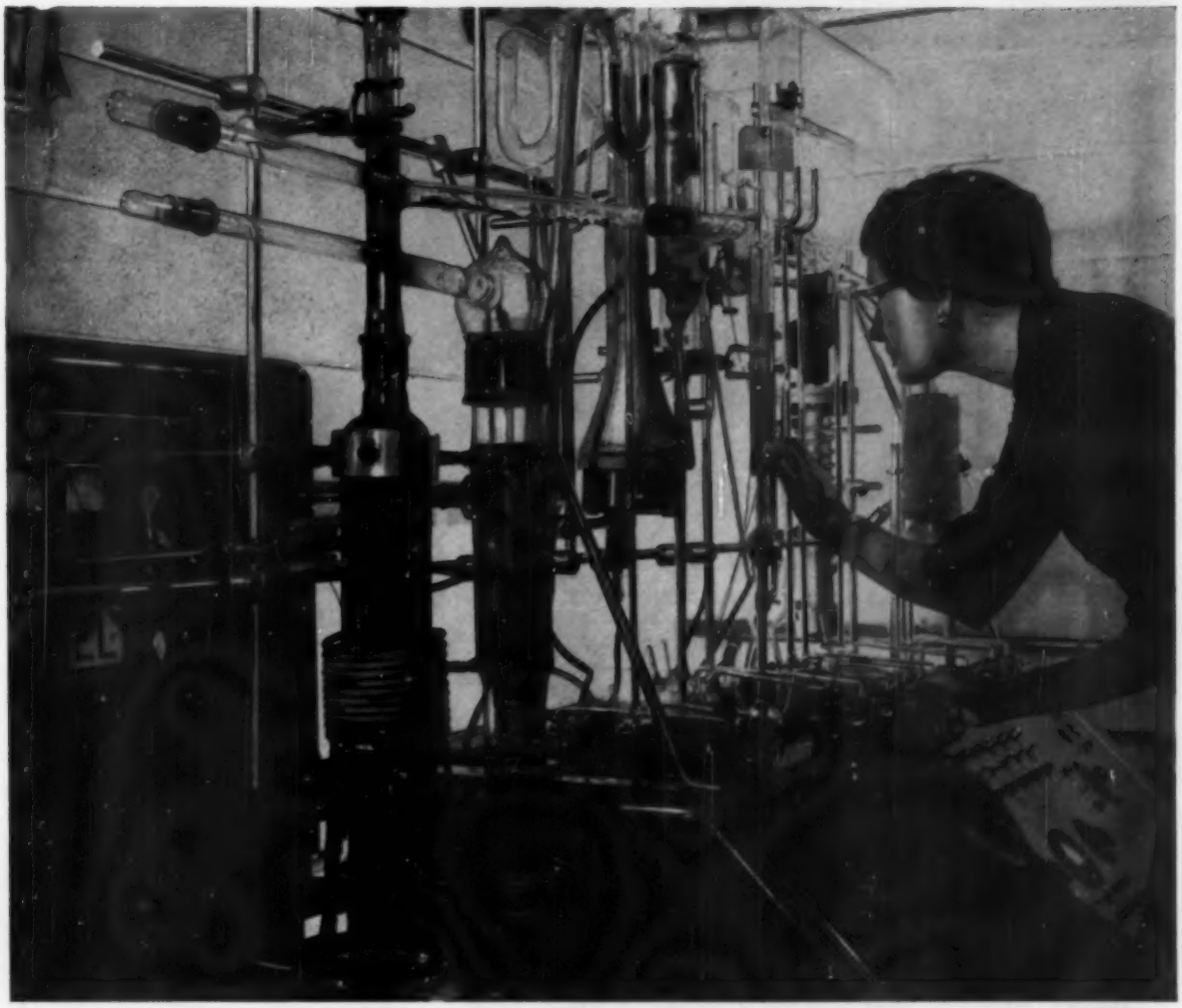
Practical Limit: 2 in. aluminum. 3 in. magnesium

*Advantages:* Sensitivity is close to radiography; minimum operator fatigue; relative ease in positioning specimen, including 360° viewing.

*Disadvantages:* Initial cost and maintenance are higher, since the technique requires specialized X-ray equipment and specimen-handling equipment.

**Summary** – For conventional and high-brightness fluoroscopy, standard or slightly modified industrial radiographic equipment is used. For high-definition fluoroscopy, the equipment must be of a modified design. Since high-definition fluoroscopy depends upon a magnified image (to reduce the effect of screen grain size) and intense X-ray output (to provide optimum screen brightness through a given part), the X-ray equipment should employ the smallest possible focal spot to permit image magnification with a minimum of distortion.

A.G.G.



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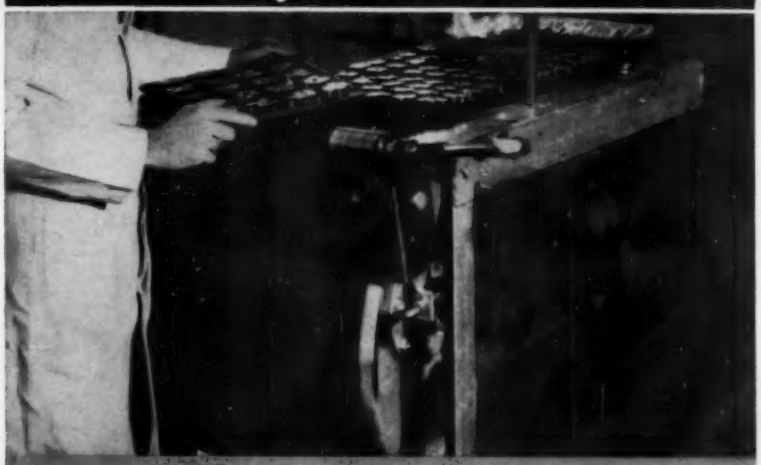


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# Nitrogen in Stainless Steels

Summary of six papers presented at the Electric Steel Conference, A.I.M.E., Pittsburgh, Dec. 5, 1957.

NITROGEN-BEARING austenitic steels have entered a wide market, due to the excellent range of properties they possess. The low-carbon $N_2$-Mn-Cr steels have all the beauty of the commonly used austenitic stainless plus durability, workability and corrosion resistance. In some applications requiring a nonmagnetic alloy, the $N_2$-Mn-Cr steels have been more resistant to transformation during magnetic conditions by mechanical working than some of the chromium-nickel steels of the A.I.S.I. 300 types.

The matter of nitrogen solubility is therefore very interesting. Using the binary diagrams which have appeared in the literature, Langenberg and Day calculated the maximum nitrogen content* in any given series of complex iron alloys containing the elements shown in Fig. 1, where $S_n$ is "the nitrogen solubility index."

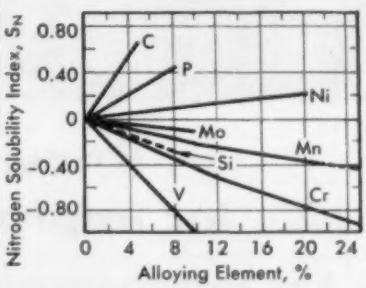
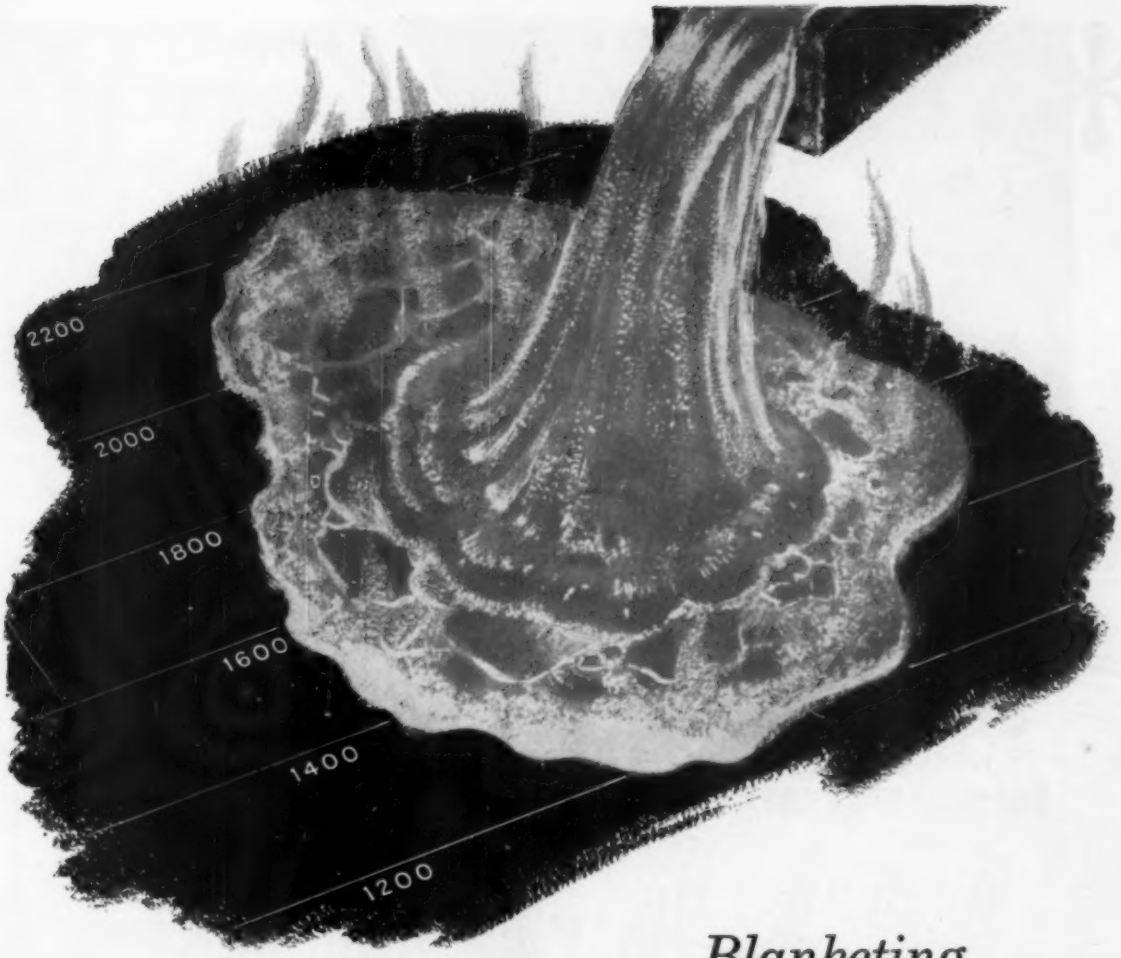



*Fig. 1 – Nitrogen Solubility Index in Steels at 1600° C. (2910° F.) as Affected by Presence of Various Common Alloys. Elements with lines inclined upward decrease nitrogen solubility in liquid steel; elements with lines downward increase nitrogen solubility*

The authors calculated the maximum solubility in nitrogen in 30 typical alloy steels by an algebraic method described in the paper. Heats of the corresponding analyses

*"Application of Nitrogen Solubility Data to Alloy Steelmaking", by Frederick C. Langenberg and Maurice J. Day, Crucible Steel Co. of America.

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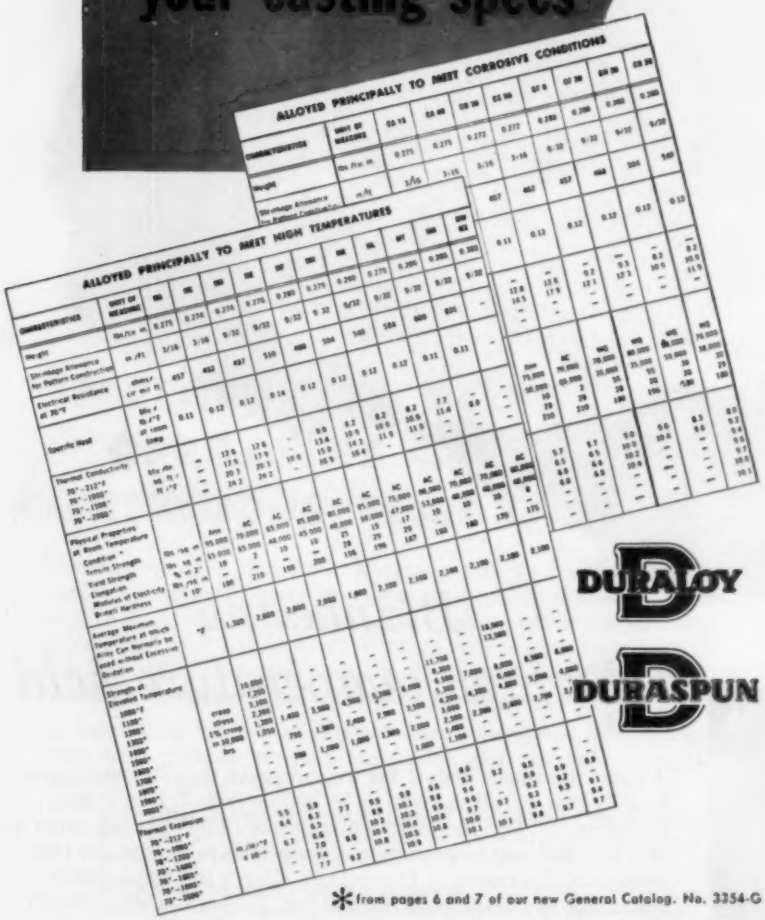
# TABLES to help you select the proper alloy for your casting specs

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*from pages 6 and 7 of our new General Catalog. No. 3354-G

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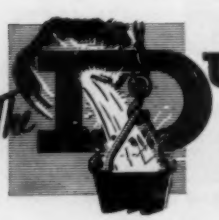

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## Nitrogen . . .

were then made and chemical analyses closely checked the predictions. For example, an 80-5-15 Fe-Cr-Mn alloy contained 0.13% $N_2$ (prediction 0.14%); a 74-18-8 Fe-Cr-Ni alloy contained 0.19% $N_2$ same as computed; a 93-2-5 Fe-V-Mo alloy contained 0.077% $N_2$, (prediction 0.078%); a 56-16-16-12 Fe-Cr-Mn-Ni alloy analyzed 0.27% $N_2$ (predicted 0.26%).

Not only must the solubility at saturation of nitrogen in liquid steel be considered, but also the solubility relationships in a solid state. Evolution of nitrogen can cause porosity in the solidified metal.

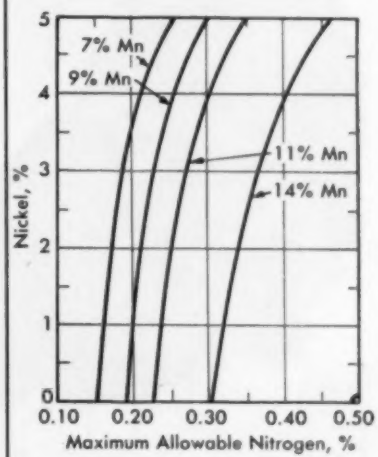
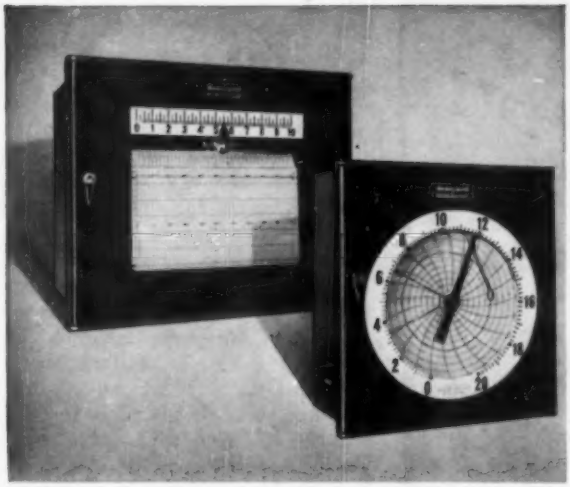



*Fig. 2 – Nitrogen Analyses to Right of Any Curve for the Cr-Mn Steels Will Produce Gassy Ingots. Base composition of the steel is 17.5% Cr, 0.4 to 0.5% Si, 0.06 to 0.08% C*

To illustrate this relationship, two series of heats were melted in an induction furnace under 1 atm. of nitrogen. The base composition was 16% Cr and 15% Mn, respectively; in both series nickel was varied from 0 to 10%. To insure saturation, more nitrogen than the predicted maximum was added as nitrogen-bearing ferrochromium. Forty minutes after the last addition, a 1-in. bar was cast. It was observed that as nickel *increased* in the alloy, the solid solubility of nitrogen also increased, although Fig. 1 shows that nickel *decreases* the solubility of nitrogen in the molten alloy. This discrepancy is explained by the fact that nickel is an austenite former and has little effect on the solid



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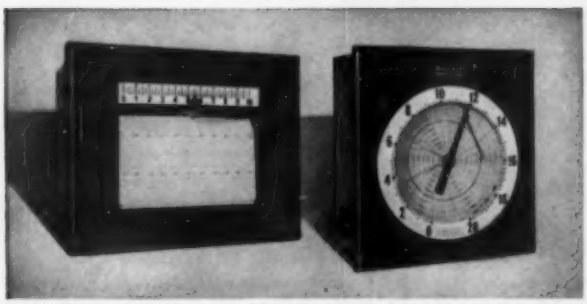

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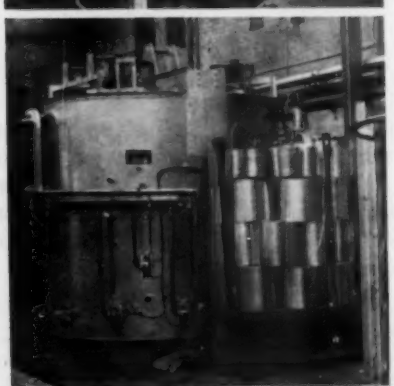

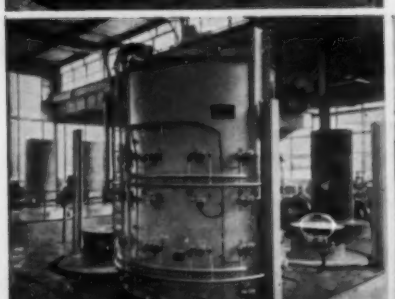

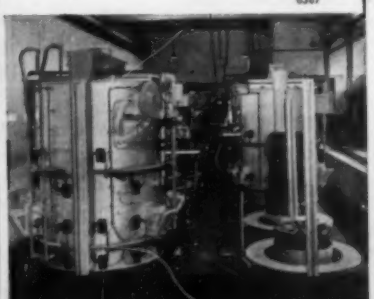

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## Nitrogen . . .

solubility of nitrogen in austenite, and that no ferrite is found in the high-nickel alloys when solidified.

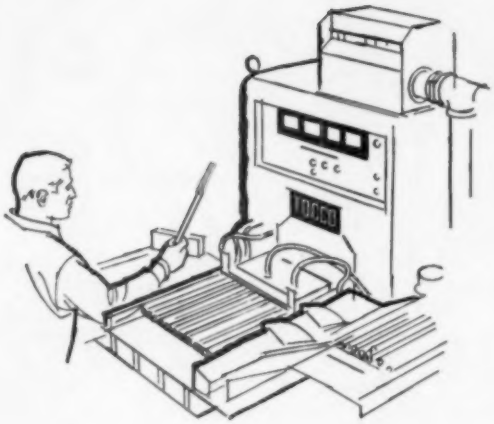
The authors cite numerous analyses which can carry nitrogen at any desired level up to 0.3% with a complete lack of porosity from excess nitrogen dissolved in the liquid steel.

A similar paper was presented by G. R. Adams, J. Thompson and W. O. Binder of Electro Metallurgical Co. These investigators melted about 90 laboratory heats of 17.5% Cr, 0.06 to 0.08% C in a basic-lined induction furnace. Composition ranged from 0 to 5% Ni and 7 to 14% Mn with varying amounts of nitrogen up to 8 ppm. Two-inch square ingots were sectioned longitudinally to reveal porosity, attributed by the authors solely to the rejection of nitrogen during solidification in excess of solid solubility limit. Results were rated from 1 to 5, the upper figure representing the maximum amount which could be retained without porosity. Results are shown in Fig. 2, and agree very well with those obtained by Langenberg and Day from Fig. 1. Nitrogen-bearing 17.5% Cr steels free from porosity can evidently be made with good assurance of success.

R. H. Colin of Duquesne Steel Works discussed in considerable detail‡ the Kjeldahl wet chemical method. He questioned whether uniform samples for nitrogen analysis could be obtained from the electric furnace bath. A bomb type of mold has therefore been used to obtain samples at four different locations and depths of the bath. Preliminary tests show very uniform results in all grades except Type 321 (18-10-Ti) if three factors are under control – namely, accurate analyses, reproducible sampling practice, and homogeneous distribution of nitrogen in the bath. The amount of nitrogen present ranged from 0.029 to 0.033% before the ferro-alloy addition. Nitrogen increased in final tests to 0.040%, due to absorption under the arc and in teeming.

Several rapid methods for nitrogen in preliminary tests (before nitrogen

‡"Sampling and Analysis of Nitrogen in Electric Furnace Steels—Aqueous Solution Methods."




# Heating Costs *Cut In Half*

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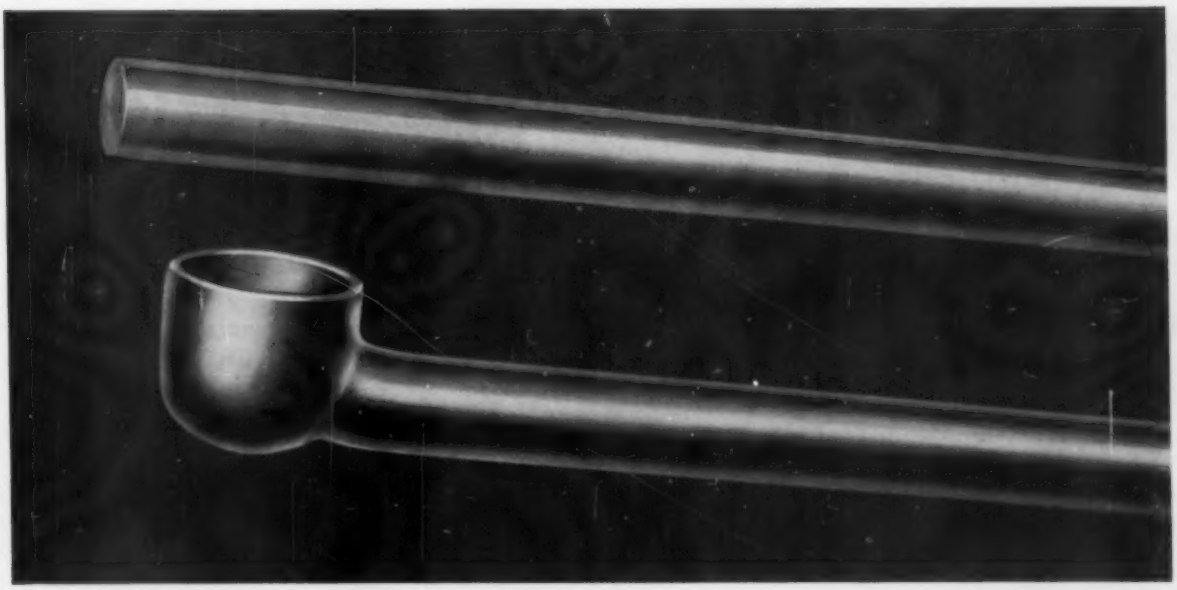

Engineers at Thompson Products Inc.'s Michigan Division recently changed from gas-fired furnaces to fully automatic TOCCO. Application: heating for forging of automotive tie rods. Result: a substantial reduction in direct labor costs, saving thousands of dollars a year on this heating for forging operation. *Annual savings actually amortize the cost of the TOCCO installation in about one year.*

The automotive tie rod shown here is only one of over 500 parts heated for forging in Thompson's new, modern forge plant. *Every one of these parts is heated with TOCCO equipment.*

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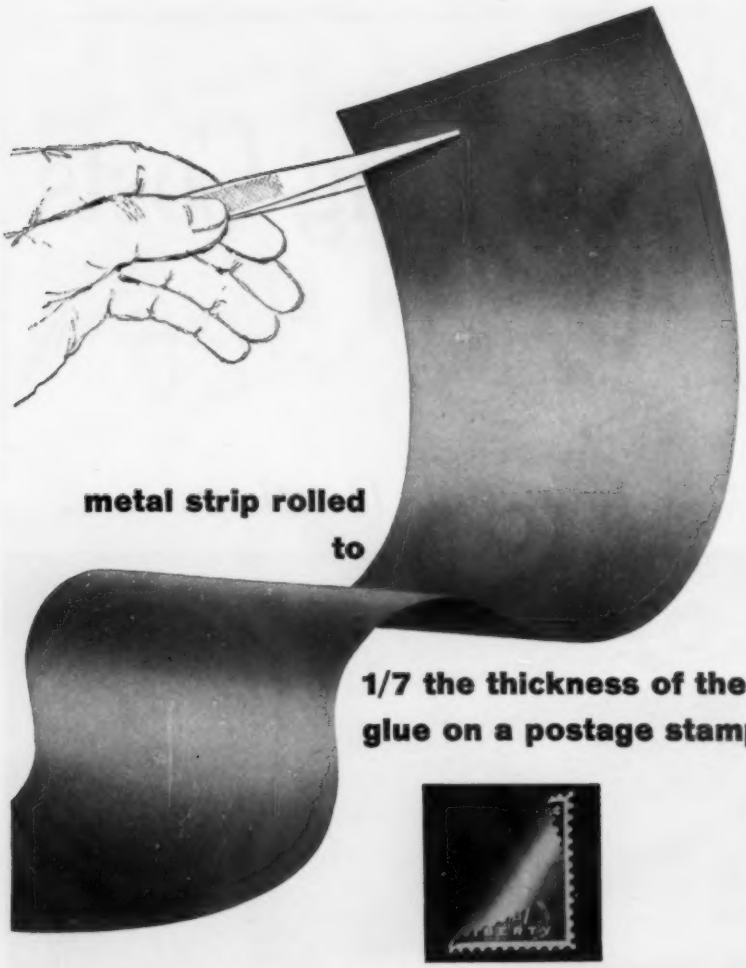


Here is metal strip—available in virtually any alloy—produced in thicknesses ranging from .010" to .0001". (The glue on a stamp measures .0007".) Many of the miniaturization problems facing designers are being solved today by this ultra-thin strip and foil from the Precision Metals Division of the Hamilton Watch Company.

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## Nitrogen . . .

alloy addition) were described. Some of them require only 10 to 20 min. Mr. Colin believes that nitride-forming elements such as titanium, zirconium, vanadium, columbium, and tantalum were finally dissolved by the boiling dilute mixture of sulphuric and phosphoric acids.

Two general forms of nitride have been recognized for years. Other chemists have been led to non-aqueous methods to obtain, if possible, information about the nitrides of specific metals.

This particular session also included three papers describing vacuum fusion processes in great detail. The description of the apparatus, methods of operation, and the results obtained were given. Contrary to the opinion above that complex nitrides can be determined by aqueous methods, it was positively stated that titanium, zirconium and other refractory nitrides are only determined in the vacuum and this is the only method to employ for materials containing regular nitrogen and zirconium.

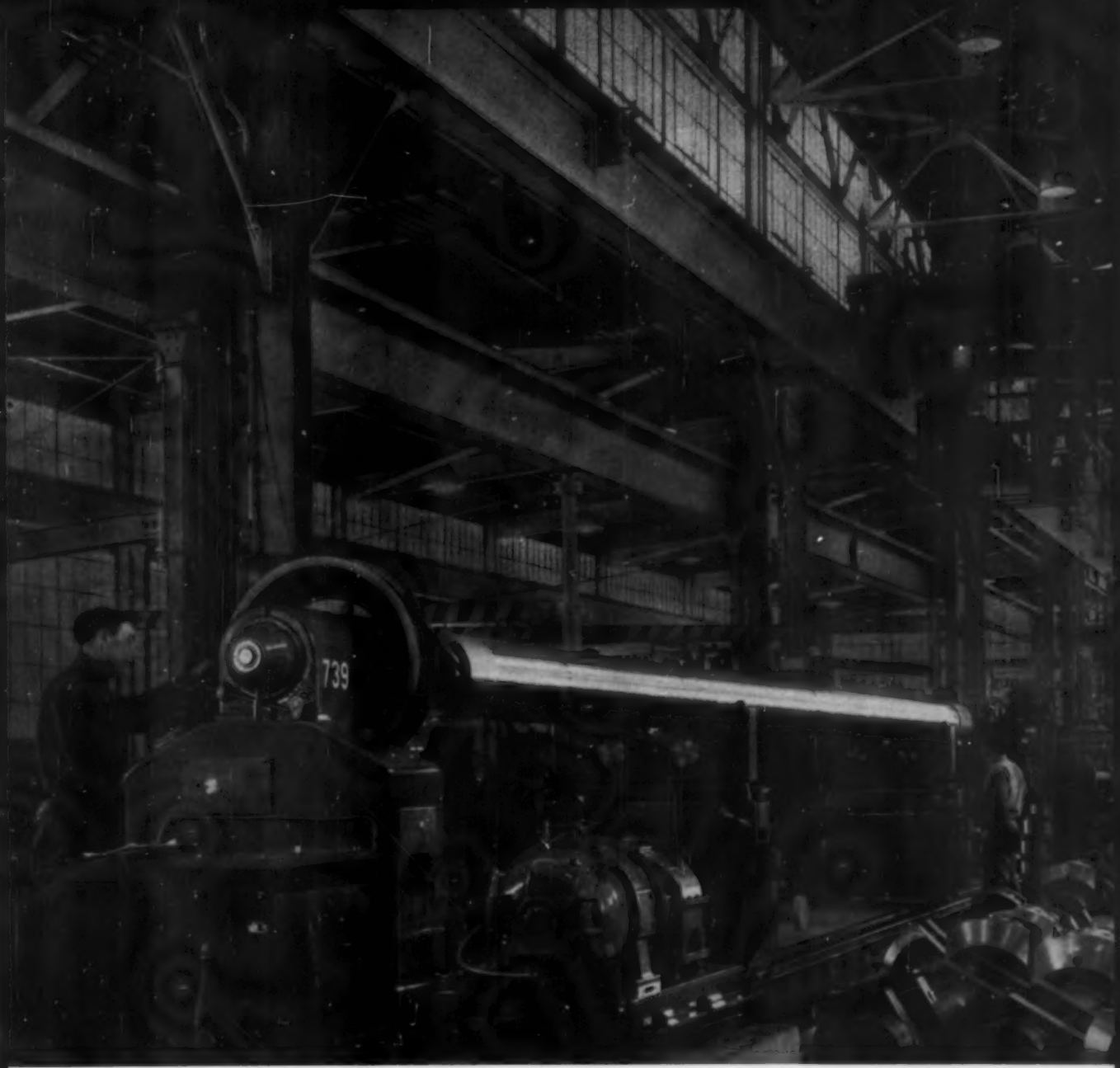
E. C. WRIGHT

## Corrosion Testing of Metals

**Digest of "The Acetic Acid Salt Spray Test", by J. H. Hooper, *Electroplating and Metal Finishing*, Vol. 10, December 1957, p. 403-408.**

PROCEDURES for corrosion testing metals and plated components have been in use for more than 40 years. A.S.T.M. standards, such as A.S.T.M. B 117, prescribe not only techniques and equipment, but pH, temperatures and humidity requirements for the accelerated corrosion tests as well.

For many years these tests, such as the 20% salt spray exposure test, have been criticized severely because of their lack of correlation to atmosphere exposure. A.S.T.M. committees studying the problem have recently suggested certain procedural modifications, such as decreasing the salt level and acidifying the test solution, in order to provide more useful data on accelerated corrosion. The present paper reports on the relative merits of various corrosion tests, and indicates the

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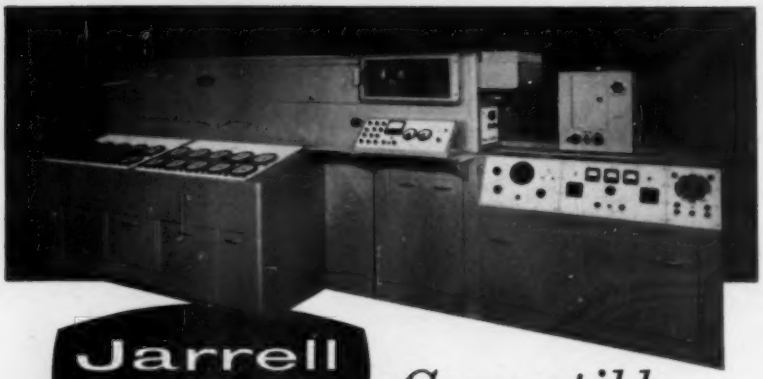

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## Corrosion Testing . . .

degree of their correlation with actual atmosphere corrosion.

The following samples were used in the tests:

1. Automobile hub caps, sawed into quarters. Specimens plated with nickel in thicknesses ranging from 0.5 to 1.5 mil.
2. Automobile hub cap quarters, with duplex platings of 0.5 mil Cu and 0.5 mil Ni, and 0.5 mil Cu and 0.75 mil Ni, respectively.
3. Zinc-base die cast flat name plates, some plated with a layer of 0.5 mil Cu and overlaid with nickel ranging from 0.5 to 1.25 mils.
4. Brass specimens, primarily for control purposes.
5. Anodized aluminum of two different purities, with anode coatings ranging from 0.1 to 0.4 mil.

Edges of all cut specimens were sealed with wax, and all surfaces were cleaned with trichlorethylene prior to exposure.

Specimens were tested variously in the following atmospheres:

1. Outside exposure, in fixed racks in a rural industrial atmosphere.
2. 5% salt solution at 60 to 75° F., solution acidulated to a pH of 3.3 by additions of glacial acetic acid.
3. Same solution as 2, except heated to 95 to 100° F.
4. Salt spray (5%) at 60 to 75° F., with a pH of 7.4.
5. Sulphur dioxide-air mixture with 95% humidity.

Results of the various tests, which are reported in detail in the original paper presented to a joint meeting of the Institute of Metal Finishing and the Society of the Chemical Industry, demonstrated extremely wide variations in test correlation. The author concludes that a 5% salt spray test has virtually no value for assessing corrosion resistance of the coatings that were tested, but does delineate gross discontinuities in the coating. The $SO_2$ test may find application as a 24-hr. quality control test for nickel-chromium deposits on steel, but is considered unsuitable for testing plated zinc or copper, or anodized aluminum.

The author reports that the acetic acid, 5% salt spray test, either hot or cold, is the most useful and universally applicable test evaluated. Results correlate closely with actual

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The American Brass Company,
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New York 16, New York.

October 25, 1957.

Gentlemen, SUMMARY OF ENGINEERING LABORATORY REPORT NO. 102587

SUBJECT: Fatigue Life Test of "Duraflex", Superfine-Grain Phosphor Bronze and Commercial Quality Grade A Phosphor Bronze spring wire.

SPECIMENS: Compression springs made from each material, were coiled on arbors to avoid tool marks. The springs had squared ends, a high pitch to obtain high stresses and were heated after coiling in boiling water for 1 hour to relieve residual coiling stresses.

CALIBRATIONS: Each spring had its physical dimensions measured with micrometers and vernier calipers and was load tested in a Comaco Elasticometer Precision Spring Testing Instrument, before fatigue testing and after each 100,000 cycles of deflection to determine loss of load, if any.

FATIGUE TESTING: A representative number of springs from each material were tested simultaneously under identical conditions.

STRESSES: The stress in the springs, including curvature correction, during the tests were as follows:

| | |
|---|---|
| Stress at Initial Installed Position | 36,600 p.s.i. |
| Stress at Final Deflected Position | 73,200 p.s.i. |
| Stress Range during deflection | 36,600 p.s.i. |

These stresses, for endurance limit testing, are exceptionally high for phosphor bronze spring wire - far higher than those ordinarily recommended for Beryllium-Copper or Stainless Steel for such severe service and are comparable to those used for good quality Spring Steel.

RESULTS: Grade A Springs broke at average deflections of 605,700.

Duraflex Springs were still satisfactory with no appreciable loss of load at 2,000,000 deflections.

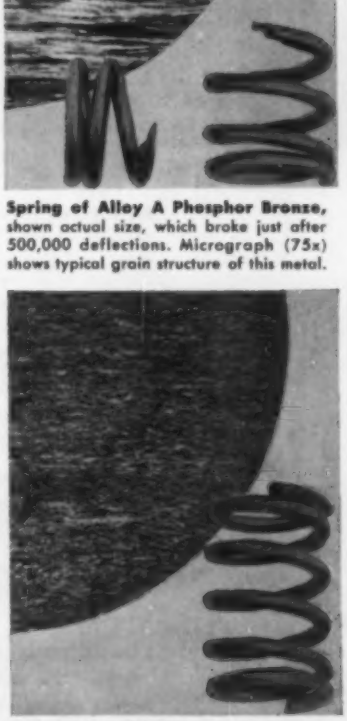
CONCLUSIONS: 1. Design stresses for Duraflex can be at least 33% higher than those used for Grade A Phosphor Bronze and as high if not higher than design stresses recommended for Beryllium Copper.

2. High endurance and long fatigue life at high stresses can be expected from springs made of Duraflex Phosphor Bronze.

CERTIFICATION: We certify the above summary of our report is accurate, in accordance with the facts and is true in every respect.

Respectfully submitted,
THE CARLSON COMPANY
Harold Carlson
Harold C. H. Carlson, P.E.
Licensed Professional Engineer.

**Spring of Alloy A Phosphor Bronze,** shown actual size, which broke just after 500,000 deflections. Micrograph (75x) shows typical grain structure of this metal.



**Spring of Duraflex** showed no appreciable loss of load after 2,000,000 deflections in same test. Micrograph (75x) shows typical superfine-grain structure of Duraflex.

Duraflex is a registered trade-mark for a higher quality phosphor bronze in sheet and wire forms, recently developed by American Brass Company research. Yet it costs no more than regular phosphor bronze. For detailed information—for a copy of the test data—write The American Brass Company, Waterbury 20, Connecticut. In Canada: Anaconda American Brass Ltd., New Toronto, Ont. 8845

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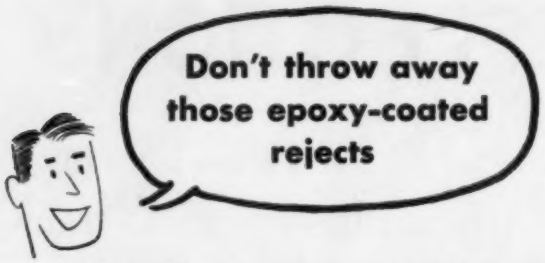


# Here's a new paint stripper that will save them

Do you scrap perfect metal parts that have been imperfectly coated with epoxies, vinyls, polyesters and other hard-to-strip paints or lacquers?

In the last few months, users of Oakite Stripper S-A have eliminated many such losses. Here's what some of them say about it:

**CALIFORNIA:** An aircraft manufacturer tested many strippers on an epoxy designed to resist attack by hydraulic fluid. Finally found that Oakite Stripper S-A is "the only one that safely strips this paint from anodized aluminum."

**NEW YORK:** A camera maker coats flash bulb reflectors with black vinyl paint outside and aluminum paint inside. "Stripper S-A is the fastest ever used on our rejects."

**OHIO:** A maker of toy pistols had trouble stripping alternate coats of lacquer and metallized aluminum. Now "Stripper S-A does it amazingly fast and remetallizing is completely satisfactory."

**CALIFORNIA:** A producer of metal furniture uses Stripper S-A to remove clear epoxy from plated parts. Chemist says "This is the best stripper on the market."

**ALABAMA:** A hardware maker had trouble stripping lacquer from brass door knobs. Oakite Stripper S-A now does the work in "less than ⅓ the time taken by any other stripper."

**NEW YORK:** A manufacturer of business machines tested several strippers on various finishes on steel and aluminum. Verdict in favor of Stripper S-A was: "It's doing a wonderful job."

**CONNECTICUT:** A maker of brass lipstick shells has found that "Stripper S-A quickly strips epoxy lacquers from rejects and heavily coated work spindles."

**CALIFORNIA:** A missile maker reports that "Stripper S-A is doing a fine job stripping vinyl from stainless steel and titanium."

**FREE** Write Oakite Products, Inc., 26H Rector St., New York 6, N. Y., for complete information on Oakite Stripper S-A.

Technical Service Representatives in Principal Cities of U. S. and Canada
Export Division Cable Address: Oakite

OAKITE
SPECIALIZED INDUSTRIAL CLEANING
MATERIALS METHODS SERVICE
SCIENCE
*In our 50th year*


## Corrosion Testing . . .

industrial atmosphere corrosion, justifying the use of acidulated spray solutions.

The author presents qualitative results of all tests, and includes photographs of 12 different specimens that were evaluated in the series. JAMES L. WYATT

## Plating . . .

(*Starts on p.* 112)

such cases the cleaning medium may be tailored to meet the requirements of the job.

5. Rinsing – This is one of the most important factors in the entire cleaning and activation process. All too often it's taken for granted. Water volume, agitation and temperature are important considerations. It is frequently possible to improve rinsing, yet actually decrease the volume of water used. It is desirable to have a warm first rinse followed by a cold rinse. Warm water removes the cleaning medium much more efficiently than cold water. Cold water prevents surface oxidation particularly during long transfer cycles.

**Specialized Finishes**

Alloy plating systems used for aircraft engines have not been advertised as have the superalloys for high-temperature applications. However, they are of equal importance in the over-all development of modern engines, Bruce E. Scott, Curtiss-Wright Corp., Wright Aeronautical Div., Woodridge, N.J., told the A.E.S. meeting. Problems solved by plating include the elimination of operational corrosion of engine parts and reduction of cavitation erosion of high-speed bearings.

As the power of aircraft engines rose after World War II, deficiencies in the lead-indium system (such as an increase in oil corrosion) led to a search for a better bearing overlay which would give the needed increase in performance. This overlay is the lead-tin alloy deposit now in production. The fluoborate plating solution gave the necessary deposition potentials of lead and tin ions to permit co-deposition in the required tin range of 6.0 to 9.5%.

**Turbine spiral case** being fabricated of USS "T-1" Steel in the shop of the S. Morgan Smith Co., York, Pa. Plates ranged in thickness from ½" to 1 15/16".

# Taming the mighty Snake River with turbine spiral cases of USS "T-1" Steel

## Stronger steel reduces weight . . . cuts costs

**Four of these** huge spiral cases are being built for the Idaho Power Company for use in the Brownlee Dam on the Snake River near Robinette, Oregon. They are designed for a 250-foot head of water. The inlet is 18 feet in diameter and each turbine will generate 144,000 horsepower at a speed of 128.6 rpm. Water will flow through the cases at a rate of 5,460 cubic feet per second.

Because of the fierce pressure, it was obvious that a strong steel was required. USS "T-1"* Steel was selected because it has a minimum yield strength of 100,000 psi. What's more, it can be fabricated, is readily weldable and has a high resistance to impact abrasion.

**Cost savings.** By using USS* "T-1" Steel, there will be substantially less shipping weight across the country and less weld time and weld metal, both in the shop and on the job site. Had carbon steel been specified, double thicknesses would have been required.

**Fabricating operations.** Projection of the dimensional outline on the plates was done with Lumitrace. Plates were cut to size by flame-cutting and rolled cold to shape. Some parts were finish welded, others were tack welded and assembled. The spiral case was then disassembled and shipped. Finish welding of segments is to be done at the dam site.

This job points up the economies possible with the use of USS "T-1" Steel. Why not use it for your own equipment? Write for our "T-1" book containing complete information. United States Steel Corporation, Room 2801, 525 William Penn Place, Pittsburgh 30, Pa.

Remember that we also make USS COR-TEN*, USS TRI-TEN* and USS MAN-TEN* Steels . . . widely used in power generation equipment.

United States Steel Corporation – Pittsburgh
Columbia-Geneva Steel – San Francisco
Tennessee Coal & Iron – Fairfield, Alabama
United States Steel Supply – Warehouse Distributors
United States Steel Export Company

USS United States Steel

*TRADEMARK

# 35,000 Specimens...
# 105,000 Photomicrographs...
## *Not One Breakdown*

***Metallurgist Byron Carns says:***

**"In the past five years at Kennametal, our AO Research Metallograph has been operated at a minimum expenditure with regard to maintenance and repairs . . . some 35,000 specimens were examined and over 105,000 photographs taken for permanent records."**

Kennametal Inc. of Latrobe, Pa. produces cemented carbides, tantalum, niobium and high temperature alloys. Their lab is a busy place and their AO Metallograph 2400P has to produce a photomicrograph on the average of every six minutes. The AO Metallograph is constantly in use on research and development as well as the routine control work that floods every industrial laboratory.

Talk to people like Byron Carns! You'll find that the AO Metallograph is designed for maximum efficiency. You perform every operation while sitting comfortably at a modern desk. You compose the picture on a screen directly in front of you . . . the camera is focused automatically while you examine the specimen through the microscope. You can take notes, change magnifications, orient specimens, make exposures . . . all with unbelievable speed, ease and precision.

Write NOW for the complete AO Metallograph story! Learn how the AO "Workhorse" can earn its keep in *your* laboratory.

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Dept. G119

Please send me information on the LABORATORY WORKHORSE...the AO METALLOGRAPH.

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## Plating . . .

Tests showed that if the tin content fell below 6% in the deposit, corrosion resistance was diminished, leading to wiping of the overlay from the bearing surface. Above 6% tin, the overlay was superior to lead-indium in resistance to operational corrosion from lubricating oil.

**Silver-Lead Alloy Plate**

Another problem was associated with the drive of a gear train. The pinions associated with the system operate at high speed, over 20,000 rpm., and at high unit loads. Initial designs called for steel-backed silver bushings with a lead-tin overlay. Experimental operation of an engine with this design revealed severe erosion of the bushings associated with the pinion gears. Examination of the failures indicated cavitation erosion brought about by the speeds and loads involved. The meshing of the pinion teeth evolved high-frequency vibrations which were transmitted to the bushing via the oil film. This resulted in ultrasonic drilling of cavities.

The problem was solved by using a silver-lead alloy electrodeposit. Lead content of the deposit was maintained in the range of 0.4 to 0.7% (Fig. 2, p. 113) to take advantage of its complete solubility in the silver. The following sequence is used to plate the steel shell:

1. Nickel strike.
2. Silver strike.
3. Silver plate, 0.002 in. thick.
4. Silver-lead plate to the required thickness.

It was necessary to use a pure silver base for the silver-lead deposit to get an adequate bond.

**Nickel-Phosphorus Plate**

Mr. Scott told how Curtiss-Wright is using this plating system to solve some of its problems. The electroless nickel deposit contains about 7% phosphorus which makes the nickel deposit precipitation hardenable upon heat treatment. This gives a plate having properties better than electrolytic nickel for certain applications. The catalytic chemical reduction method also gives an even deposit on all surfaces regardless of configuration.

One application mentioned by Mr.

# Boron

## for—non-aging sheet steel
## —nuclear modifiers

**MCA boron products are readily available in these forms:**

- **Calcium Boride**
- **Manganese Boride**
- **Amorphous Boron**
- **Ferro-Boron (11%)**
- **Ferro-Boron (17%+)**
- **Boron-Aluminum Cups**

New developments in the use of boron steels require the proper boron alloys in the steels' manufacture. Likewise, varying steel making techniques require different types of boron alloys. For each, there is a proper boron alloy, whether the objective is non-aging sheet steel or modifying rods for nuclear energy, for example. To meet competitive steel prices, manufacturers need to employ alloying elements judiciously.

MCA's long experience in boron alloys and their use in steel manufacture gives you a reliable source of information and service. Write or call today.

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**Grant Building** **Pittsburgh 19, Pa.**

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*Sales Representatives:* Brumley-Donaldson Co., Los Angeles, San Francisco
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*Plants:* Washington, Pa., York, Pa.

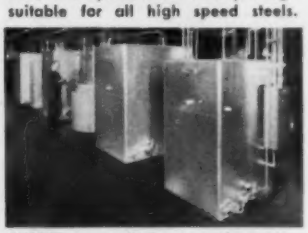
MCA

these Waltz furnaces can cut your heat-treating costs

Waltz heat-treating furnaces are "money-makers" in large and small plants throughout the country. Compact in design, efficient, their many unique features mean low cost—high production operation. Hundreds of plants have established their own highly profitable heat-treating department with Waltz Furnaces. Here are a few of the many Waltz Furnaces, using all types of fuel, available.

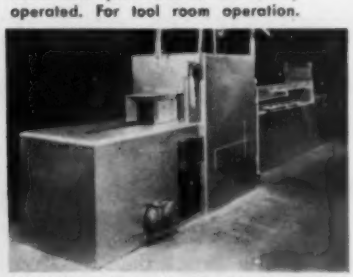
WALTZ car bottom furnace. Electrically operated. Sizes to suit.

WALTZ small tool furnace has separate pre-heat furnace, high heat furnace and quench tank. Temp range suitable for all high speed steels.



WALTZ controlled atmosphere furnaces and quench tanks. Electrically operated. For tool room operation.

WALTZ spray washing machine, gas fired. Can be integrated into production line for continuous operation.



WALTZ continuous brazing furnace is electrically operated. Designed for copper brazing or sintering.

Let WALTZ show you how to have a profitable heat-treating operation right in your own plant. Special furnaces will be designed and built to meet your specific requirement. Complete technical information available on all Waltz furnaces.

Write Dept. W.

WALTZ globar heated furnace, electrically operated. Designed for development of brazing alloys.

Waltz FURNACE COMPANY
SYMMES STREET • CINCINNATI, OHIO


## Plating...

Scott was the use of electroless nickel on piston ring grooves, as shown in Fig. 3, p. 114, to prevent piston breakage. Side-face wear in the grooves was substantially reduced by the 0.0005 to 0.0007-in. deposit. The depth and narrowness of the grooves prevented the use of normal electrodeposits without elaborate fixturing. The pistons are made from an aluminum alloy forging.

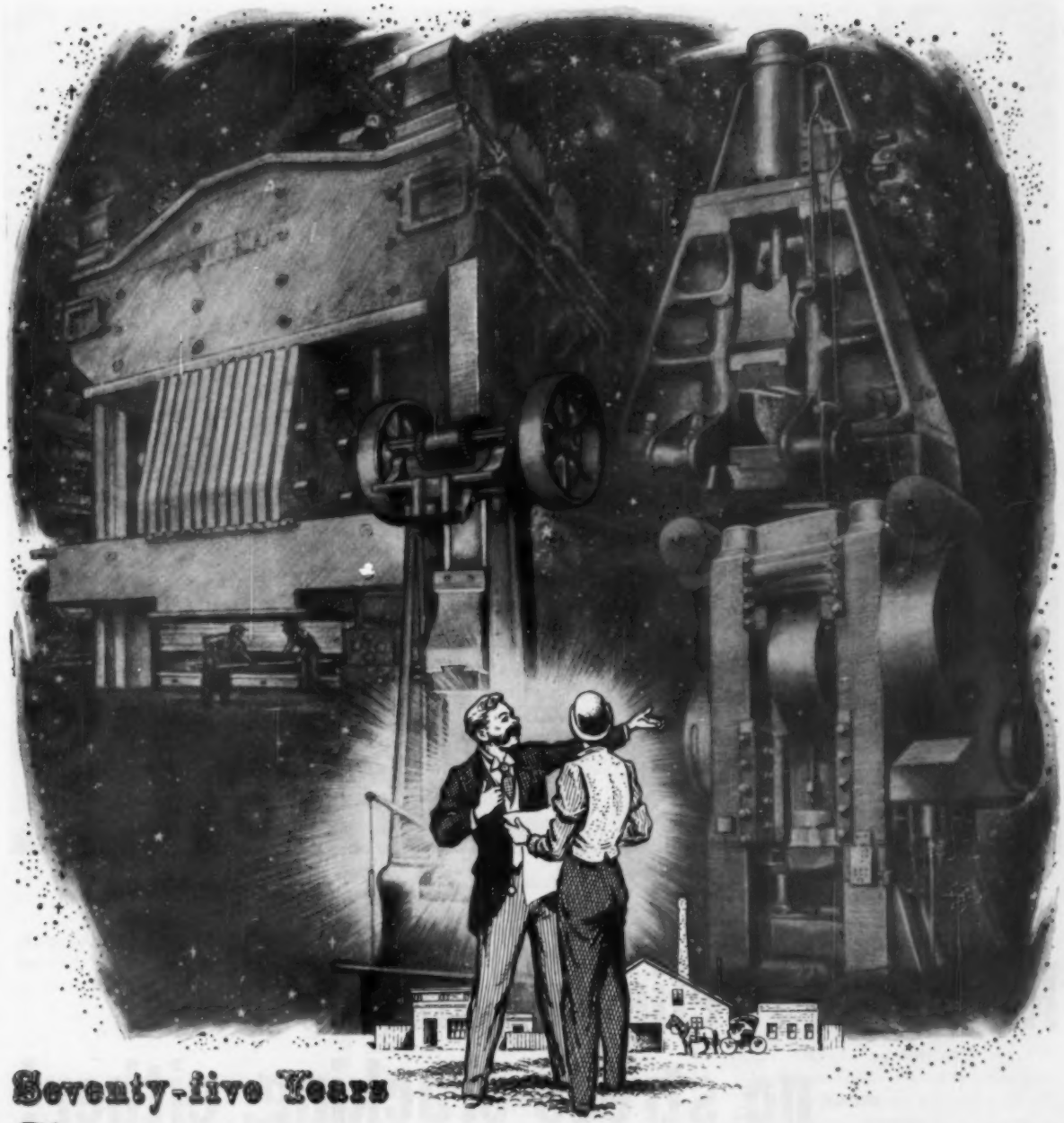
This coating was extended from the ring groove to cover the entire piston dome to protect the piston from corrosion by the combustion products of leaded fuels. Other applications of electroless nickel on aluminum parts have been made at Curtiss-Wright to reduce wear by hard surfacing. A precipitation hardening treatment at 450° F. for 4 hr. is used on all plated aluminum parts.

**Other Alloy Systems**

Mr. Scott reported that an alloy deposit containing 25 to 35% tin in a cadmium matrix shows excellent salt spray resistance. Deposits 0.0001 in. thick withstood 1000 hr. of salt spray exposure before the basis metal showed rusting. Other deposits, 0.0003 in. thick, did not show rust after 32 months exposure. The alloy deposit is produced from a fluoborate bath.

Cadmium-nickel deposits are useful for corrosion protection of steel up to 900° F. In practice, the nickel is deposited from either a chloride or a sulphate-chloride bath to a thickness of 0.0002 to 0.0004 in. This is immediately followed by 0.0001 to 0.0002 in. of cadmium from a regular cyanide bath. The part is then heated in air at 620 to 640° F. for a minimum of 30 min. This diffuses the cadmium into the nickel to give an alloy at the surface which protects up to 900° F.

Mr. Scott said that Curtiss-Wright is using a copper-tin alloy deposit for nitriding stop-off in manufacturing operations. This bronze plate replaced a pure tin deposit as a stop-off and has proved to be most satisfactory. A dual anode system is used in an alkaline bath to give a deposit containing 5 to 15% tin in a copper matrix. Control of the bath is not difficult. Mr. Scott men-



# Seventy-five Years

THERE WAS a growing surplus in the United States Treasury—the Polygamy Act was passed—letter postage was reduced from three cents to two cents—the Brooklyn Bridge was opened—standard time was adopted—in 1883, when two young men, just graduated from Worcester Polytechnic Institute, established the business bearing their names—WYMAN-GORDON. The total capital was $27,000.

Integrity, initiative, ambition and ability were theirs. Endowed with these qualities and privileged to operate under that unique American system of free, private, competitive enterprise the Company prospered and grew.

On this our 75th anniversary, we salute the spirit of our founders and we pledge our every effort to help preserve, against the steady erosion of the last quarter century, that system which has made our nation what it is today and which has enabled us to build the greatest industrial production in the world, resulting in the highest standards for all segments of our people.

## WYMAN-GORDON COMPANY

ESTABLISHED 1883

FORGINGS OF ALUMINUM • MAGNESIUM • STEEL • TITANIUM

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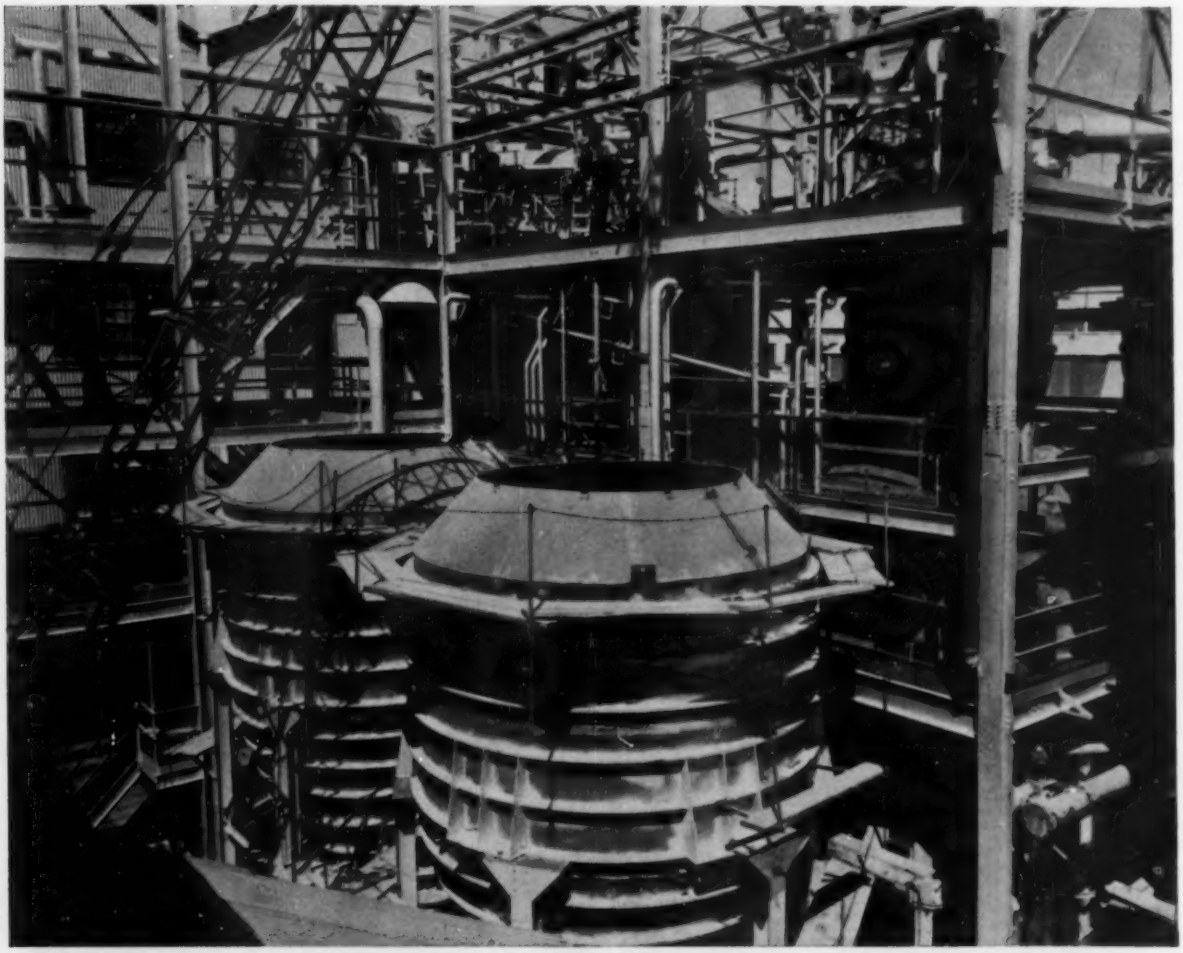


The potash crystallizers under construction above are two of seven that were shop- and field-fabricated, then field-assembled by welding. Although these units were not stress-relieved or heat-treated, there was no sign of stress-cracking after a year's service.

# No stress-relieving here —no stress-cracking, either!

## Field-assembled from NEW AMPCO METAL GRADE 8

Improved Ampco Metal Grade 8 puts an entirely new slant on fabricating copper-base alloy equipment to handle steam and corrosive media at elevated temperatures.

At a major oil refinery, for example, field-welded piping of Ampco Metal Grade 8 has handled hot sulphuric-acid sludge for a year and a half without stress-cracking.

New, patented Ampco Metal Grade 8 also simplifies field repairs and alterations. You can weld readily with any electric process, without pre-heat or post-heat and without hot-short cracking.

Talk this over with your Ampco field engineer. Or write *Ampco Metal, Inc., Dept. 21-G, Milwaukee 46, Wis. West Coast plant: Burbank, Calif. — Southwest plant: Garland (Dallas County), Texas.*

TS-6

AMPCO®

## STRAITS TIN REPORT

New developments in the production, marketing and uses of tin

MALAYAN TIN BUREAU


The Fish and Wildlife Service of the U.S. Department of the Interior has reported that "packaging frozen fish in tin results in superior storage life." Only tin prevents the deteriorating action of seeping oxygen on frozen fish in cold storage over a period of months.

**Considerable laboratory progress has been made in the electroplating of tin as a bright coating through the addition of certain wood tars to the electrolyte. Some observers feel there is a distinct possibility that this bright tin plating may take the place of metal polishing in many applications throughout the metal industry.**

A new machine has been designed in England to help speed up mass production soldering. It consists of an electrically heated solder bath with motor-driven pump to provide a stationary wave of fresh solder, which is exposed to moving printed circuit boards.

★ ★ ★

An invention was recently patented which is expected to lengthen the life of heavily stressed bearings from a few weeks to several years. A mesh of tinned wire is embedded just below the surface of babbitted bearings before pouring . . . to prevent movement in the bearing surface leading to fatigue, cracking and spalling.

Ask us to send you TIN NEWS, a monthly letter. It will keep you posted on tin supply, prices, new uses and applications.

**The Malayan Tin Bureau**

Dept. 25G, 1029 Connecticut Ave., Washington 6, D.C.


## Plating . . .

tioned that a silver-tin alloy deposit is in the development stage for use in sleeve bearing applications where hardness slightly greater than silver is needed.

**Hard Anodizing**

This process is used to give a hard finish on aluminum alloys to reduce wear. Harold J. Wiesner, Bendix Aviation Corp., South Bend, Ind., told how his company is applying it to aircraft fuel metering components. Thin hard coat, heavy hard coat and combinations of both can be produced on components to controlled thicknesses. Thin hard coat may be satisfactorily sealed and it will act as a "stop-off" during heavy hard coating.

Dr. Wiesner reported that Bendix uses the Alumilite process. The solution and operating conditions are given below:

*Sulphuric acid* – 12% by weight (7.5 gal. commercial acid per 100 gal. of bath).

*Oxalic acid* – 1% by weight (11.75 lb. per 100 gal. of bath).

*Temperature* – 48 to 52° F.

*Current density* – 36 amp. per sq.ft.

*Voltage* – 10 to 75.

*Time* – about 20 min. per 0.001 in. of coating.

*Agitation* – mechanical and/or air plus anode rod agitation.

The production tank used at Bendix is lead lined, 2½ ft. wide by 3 ft. deep by 5 ft. long. Cooling is accomplished by direct expansion of Freon into lead coils which line the periphery of the tank and the bottom. The compressor is a 7.5-hp. unit which permits cooling to 15° F., if necessary.

Dr. Wiesner stated that the 48 to 52° F. range was satisfactory on parts of average size and cross section. However, on small pieces of thin cross section or very large pieces drawing high current, there was a tendency for burning. Use of more violent agitation (such as air) to improve heat transfer often resulted in contacts being snapped off. A drop in temperature to 35 to 45° F. was beneficial. Figure 4, p. 114, shows typical parts finished by the hard anodizing process.

Thin hard coat finishes (0.0003 to 0.0007 in. thick) are sealed in a di-


MALLEABRASIVE

MORE RIDES

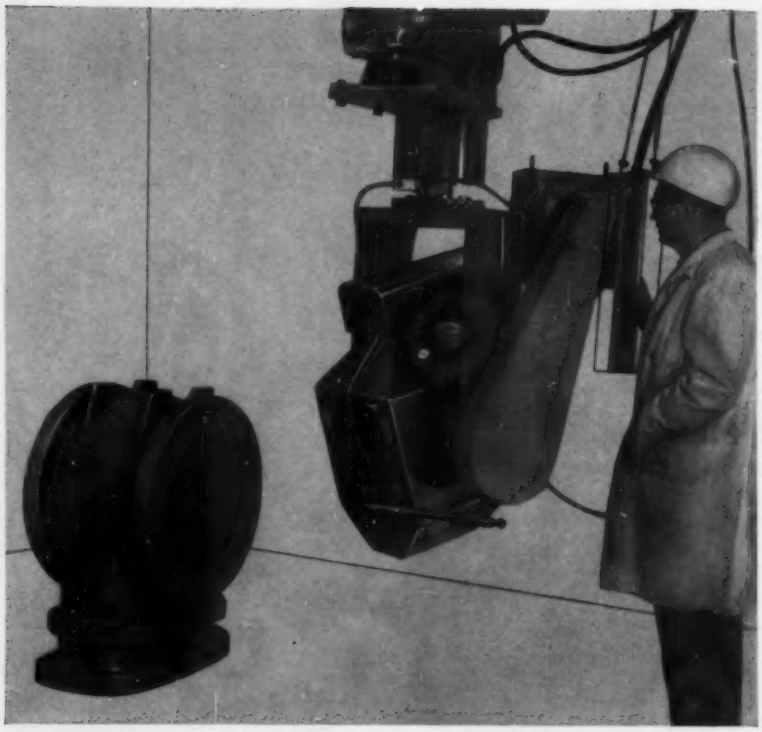
Malleabrasive goes for "more rides"—retains its grade particle size longer—has longer cleaning life, because of its own exclusive metallurgical structure—found in no other metal abrasive.

Tough and shatter-resistant, its slow breakdown rate prevents the excessively fast accumulation of "fines" that slow up cleaning, destroy machine replacement parts and build up cleaning costs.

Yes, cleaning costs are lower with Malleabrasive—proven in plant after plant. We'll show you why—cite you cases. Write us.

THE CLEVELAND STEEL ABRASIVE CO.
Mansfield, Ohio

Sold by Pangborn Corp., Hagerstown, Md., and by many leading distributors of foundry supplies from coast to coast.



**NOW... GAMMA RADIOGRAPHY THROUGH ONE FOOT OF STEEL!**

Dominion Foundries and Steel Limited, Ontario, Canada, is currently using gamma radiography to inspect steel castings up to 12" thick.

The machine doing the job is Nuclear Systems' Model 1060 Multitron, which has a capacity of 1,000 curies of Cobalt 60, and which gives results comparable to those of a 2,000,000 volt X-ray machine . . . at less than ⅓ of initial equipment cost.

Provided with completely fail-safe automatic controls, the beam producing 1060 is easily and safely operated from a remote control panel.

Call on Nuclear Systems for your radiography equipment needs. Offices in Philadelphia, Chicago, San Francisco and Los Angeles. Sales representatives in principal cities. Catalog and reprint upon request.

WRITE FOR FREE REPRINT WHICH TELLS THE STORY OF LARGEST COMMERCIAL RADIOGRAPHY MACHINE IN USE.

NUCLEAR SYSTEMS | Budd

A DIVISION OF THE BUDD COMPANY, Philadelphia 32

## Plating...

lute nickel acetate solution. Bendix has found that high-copper alloys, such as X-2219, 2024 and 2017 may be satisfactorily hard coated in a solution containing 385 g. per l. sulphuric acid with 11 to 15 g. per l. oxalic acid at a temperature below 50° F. At lower sulphuric concentrations (225 g. per l., for example) the results are erratic.

Aircraft gas turbines could be run at substantially higher temperatures if buckets made of molybdenum-base alloys could be used. Because molybdenum oxidizes rapidly above 900° F., it can be used only if protective coatings are developed. Many coating systems have been proposed and in some of these chromium plate is the first layer.

In discussing the development of a method for measuring chromium plate thickness on molybdenum, Ottis L. Isaacs, General Electric Co., Aircraft Gas Turbine Div., Cincinnati, stated that turbine buckets are difficult to plate uniformly with chromium because of their concavities, and their sharp corners and edges. Also contributing to the difficulties is the relatively poor throwing power of chromium baths. Mr. Isaacs emphasized that the chromium plate must be reasonably uniform in thickness. Otherwise, thermal stresses may result when the bucket is heated and the diffusion layer may be too thin in certain areas.

These points indicate the need for a nondestructive method of measuring chomium plate thickness on molybdenum alloy turbine buckets for quality control. Mr. Isaacs described the X-ray method which has been developed to do this job. It is rapid, accurate and independent of magnetic properties of the metals involved. The instrument used is a GE-XRD-3, X-ray diffraction unit. It measures the intensity of the fluorescent radiation from the molybdenum basis metal. The thicker the chromium plate, the weaker is the intensity of the emergent radiation.

Surface active agents are finding increased use in chromium plating baths to minimize objectionable fumes emitted from the bath and reduce loss of chromic acid by drag-out. A fluorinated surface active

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# ROLOCK

SPECIALIZED WELDED HEAT AND CORROSION RESISTANT FABRICATIONS

*for example*

**VACUUM RETORTS**

This heavy INCONEL Vacuum Retort is one of a number of such designs being produced by ROLOCK. Approximately 2 feet in diameter by 8 feet high, it is used for high-temperature vacuum annealing.

By entrusting such work to Rolock, you gain the many advantages of competent engineering supervision; production personnel thoroughly experienced in the problems and materials involved; a modern plant fully equipped for inspection and testing as well as fabrication.

Rolock facilities and skills cover a wide range of work in pressure and vacuum equipment, specialized processing carriers, furnace retorts, covers and bells, trays, tanks, fabrications and assemblies in Inconel, Incoloy, Monel, the Hastelloys, and Stainless Steels. Send us an outline of your requirements.

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JOB-ENGINEERED for better work
Easier Operation, Lower Cost

3RLSBA


## Plating...

agent, known commercially as Zero-Mist, is used for this purpose. Donald R. Millage, Udylite Corp., Detroit, gave details of a study made to determine the influence of surface active agents on pitting in thick chromium deposits. The technique used involved drilling a microhole in the basis metal and plating it in a chromium bath with and without a surface active agent.

He reported that porosity of the basis metal is the cause of hydrogen pits in chromium plate which is deposited from a bath containing a surface active agent. If the same basis metal is plated in a bath which does not contain a surface active agent, the chromium plate will attempt to bridge the defective area of the basis metal.

If the chromic acid to sulphate ratio of the bath is somewhat above 130 to 1, defective circular areas (sometimes called low-catalyst pits) will form on the thick chromium-plated cathode. Mr. Millage stated that the fluorinated surface active agent has a profound effect on these low catalyst pits; at a given chromic acid to sulphate ratio, both the rate and intensity of their formation are increased. With this effect in mind, he stated, it should be remembered that when a fluorinated surface active agent is used in chromic acid plating solutions, the effective chromic acid to sulphate ratio is much higher. This is important from the standpoint of somewhat improved corrosion resistance of decorative chromium deposits in the range of 20 to 60 millionths of an inch thick. Mr. Millage also stated that outdoor and accelerated corrosion tests have shown that the fluorinated surface active agent has no influence on the natural intrinsic porosity of chromium plate which is 5 to 20 millionths of an inch thick.

## Carbon Control

Digest of "Carbon Equivalent Concept", by K. G. Lewis and J. McCracken, *Iron and Steel*, Vol. 30, May 1957, p. 165-169; June 1957, p. 207-213.

CONTROLLING the proportions of scrap and pig iron or hot metal charged to basic openhearth furnaces results in shorter heat times

# MOLY NEWS

CLIMAX MOLYBDENUM • DIVISION OF AMERICAN METAL CLIMAX, INC.


## Climax Develops an Extremely Tough, Abrasion-resistant Chrome-Moly White Iron

### New Alloy Proves Superior in Erosive Applications

A new martensitic white iron has proved exceptionally tough and resistant to abrasion. It's called Alloy 42. Its excellent combination of properties are related to its structure — which consists of hard chrome-moly carbides favorably distributed in a matrix of martensite plus retained austenite.

Tests indicate Alloy 42 is especially economical for parts subject to erosive wear: sand pumps, flotation impellers, sand classifier wear shoes, pug mill blades, brick mold liners and chute liners.

For example, heat-treated Alloy 42 impellers in a 5" sand pump handling coarsely ground taconite ore have already lasted over 1,000 hours. Previous impellers made of a 4.5% Ni, 1.5% Cr type of martensitic iron lasted only 350 to 400 hours.

Because of its toughness, Alloy 42 can also be used where moderate impacts would cause low alloy types of white iron to break or spall. And it may prove more economical than the soft rubber parts or linings now used in various abrasive applications. Its resistance to tearing by tramp coarse materials and chemical attacks by oils and other organic compounds is an obvious advantage.

The recommended composition range is: Carbon 3.00-3.50%; Silicon 0.30-0.60; Manganese 0.60-0.90; Chromium 15.0-18.0; Molybdenum 2.75-3.25.

A Climax bulletin on Alloy 42 discusses melting and casting, molds and shrinkage, heat treatment, structure, physical properties, machinability, welding and cutting. *For a free copy, circle #1 on the coupon.*

### Heat Treating Improves the Wear Resistance of Gray Iron

Heat treating can improve many of the properties of gray iron, particularly resistance to wear. Wear resistance in quenched-and-tempered gray iron is many times greater than that of pearlitic irons. With cams and similar parts, hot quenching provides better wear resistance than quenching and hardening to the same hardness. Surface hardening is frequently selected for gray iron because it locally improves wear resistance with minimum distortion.

***Why Moly Iron Bulletin #6*** contains valuable information on surface hardening, annealing and stress-relieving molybdenum-alloyed irons. This bulletin gives examples of improvements obtained by heat treating gears, cable drums, pump-ring castings, tappets, valve guides and machine tool ways.

**Flame hardening the teeth on a sprocket improves wear resistance with minimum distortion.**

*For a free copy of "Why Moly Iron Bulletin #6," circle #2 on the coupon.*

### Tempering Low-Alloy Creep-Resistant Steels

A recent British paper discusses the roles of chromium, molybdenum and vanadium in low-alloy steels with high creep strength. The relation between creep properties, microstructure changes and carbide composition is given special attention.

*For a copy of "The Tempering of Low-alloy Creep-resistant Steels Containing Chromium, Molybdenum and Vanadium" by E. Smith and J. Nutting, circle #6.*

### Moly Helps High Alloys Fight Corrosive Attacks

Highly alloyed materials are playing a greater part in combating corrosion. A current paper on these alloys considers the molybdenum-bearing alloys at length and also discusses cobalt-base alloys and silicon-bearing alloys.

*For copies of this paper, "High Alloys to Combat Corrosion" by E. D. Weisert, circle #7.*

### Thermenol Shows Excellent Resistance to Heat, Corrosion

Thermenol, an iron-aluminum-molybdenum magnetic alloy, compares favorably with other high-temperature materials, and in some cases promises even better service. For unlike many alloys, it doesn't lose tensile strength rapidly up to 1200 F. It also has excellent resistance to oxidizing and sulfur-bearing atmospheres at high temperatures.

*For a copy of "Iron-aluminum Magnetic Alloy Has Excellent Heat Resistance," circle #8.*

### Moly in Nickel-base Casting Alloys Improves High Temperature Service

Molybdenum is helping at least two nickel-base alloys to work more effectively in high temperature applications. One of the alloys, with 5% Mo, combines good castability with very good creep strength at temperatures up to 1800 F (much better than that of moly-free alloys). The second, with 10% Mo, shows high resistance to thermal shock.

*For free copies of "Some Properties of Nickel-base Casting Alloys for High-temperature Service" by D. R. Wood and J. F. Gregg, circle #3.*

### Cast Steels Studied at Low Temperatures

The British Steel Castings Research Association has completed new studies on the effect of melting practice, composition and treatment of steel castings. Five of the seven alloy steels investigated contained molybdenum. The benefits of using molybdenum in low alloy steel castings for low temperature service are clearly shown in comparisons of 1.5% Mn and 1.5% Mn-Mo.

*For reprints of "The Low-temperature Impact Properties of Cast Steel" by W. J. Jackson and G. M. Michie, circle #4.*

### New Data Available on Low Carbon Bainitic Steels

Studies have been made on new steels based on boron-0.5% Mo. Tensile strengths up to 180,000 psi can now be obtained within the bainitic range with a wide range of cooling rates. Thus these low-carbon bainitic steels offer a good combination of mechanical properties as-rolled or as-air-cooled. These properties can be obtained in large sections because hardenability is high. Good welding properties and tempering characteristics make the steels especially suitable as high-strength weldable steels, forgings, die blocks, etc.

*For copies of "Low-carbon Bainitic Steels" by K. J. Irvine and F. B. Pickering, circle #5.*

Climax Molybdenum, Dept. 5
Division of American Metal Climax, Inc.
500 Fifth Avenue, New York 36, N. Y.

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## Carbon Control . . .

and lower costs. The objective is to obtain a specific carbon content, temperature, and slag basicity at the end of the melting period. The melting period is considered complete when the last scrap is melted and the lime rises from the bottom. Many authorities consider it best to melt at 0.40 to 0.70% C above the level desired at the time of tapping. When the carbon content is too high, extra additions of ore, mill scale or oxygen are required. On the other hand, hot metal or pig iron additions must be made if the meltdown carbon content is too low. Either way, production costs and heat times will increase.

The duration of the melting period depends on the charging practice as well as furnace characteristics and the chemical reactions involved. The hot metal additions should be timed according to the degree of oxidation of the molten or partly melted scrap. Delays result from adding hot metal so early that it will be chilled by cold scrap and will remain relatively dormant under a cold slag. Conversely, if hot metal additions are delayed too long, the scrap will be excessively oxidized. This results in a foamy slag which is a poor heat conductor, and the bath will be sluggish once the initial vigorous boil subsides.

The chemistry of the melting period is also important. Silicon, manganese and phosphorus are oxidized from the bath and contribute to the slag. Since these elements compete with carbon for the available oxygen, they help to govern the melting period. They should be taken into account in proportioning the charge. The oxidation requirements per unit weight of each element can be summarized in terms of its carbon equivalent. The carbon equivalents are 0.855 for silicon, 0.968 for phosphorus, and 0.219 for manganese. These values can be multiplied by the appropriate analyses and percentages of scrap and iron making up the furnace charge. This gives the carbon equivalent (CE) to be oxidized from the charge, a figure sometimes termed the metallurgical load on the furnace. The authors consider it essential to include in the calculations contributions from the scrap. Their data

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*The story of Wissco Belts is best told by their users.* For instance, Mr. Carl Smith, Heating Foreman of Forest City Foundry, says:

**"Our Wissco Belts have consistently given us good performance through a long service life and low down time."**

Two Wissco Belts are used to carry castings through an annealing furnace, where temperatures range from 1100° to 1600°F, and a normalizing furnace used for stress relief of castings. The heaviest castings weigh 284 pounds each, or a total load of 2500 pounds on the 16 foot long belt.

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Wissco Belts have increased the efficiency of many process-conveying operations by increasing service life and reducing down-time. Put Wissco Belts to work for you.

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PRODUCT OF WICKWIRE SPENCER STEEL DIVISION
THE COLORADO FUEL AND IRON CORPORATION

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## Carbon Control . . .

indicate that the oxidation of silicon, phosphorus and manganese influence the meltdown carbon content.

Other factors being equal, charges with higher carbon equivalents will melt at higher carbon contents. The actual meltdown carbon will vary with furnace and fuel characteristics. In fact, the oxidation rates of a furnace increase with time, so soft heats are more likely to occur late in a campaign. The metallurgical load is a rough guide to slag volume.

These concepts were applied to operations in an English steel plant. The study showed that the correlation between carbon equivalent of the charge and meltdown carbon was significantly improved by taking melting time into account. On the other hand, the authors agree with others that the correlation between melting time and carbon content at meltdown is not significant. By controlling furnaces charges on the basis of carbon equivalent, the authors halved the consumption of mill scale and cut lime additions by 20%. The latter change decreased slag volume some 13%. With their furnace practices, dropping the carbon equivalent from 2.7 to 2.5 lowered the meltdown carbon about 0.15%.

Other data indicated that the metallurgical quality of steels after rotary piercing was influenced by the carbon equivalent of the charge. The percentage of billets showing subsurface "hairlines" was used as a measure of quality. The percentage of billets with "hairline" defects was small for heats fitting the normal relationship between meltdown carbon and the expression

$$\frac{\text{CE charge} - \text{CE melt down}}{\text{CE charge} \quad \log (\text{melting time})}$$

The defects were more numerous in heats not conforming to the common relationship with that expression. This indicates that the inferiority correlates with irregular oxidation of the whole metallurgical load rather than with oxidation rates of carbon alone. The data also show that the defects were least common in the steels melting 0.25 to 0.75% C above the 0.15% desired in the final product. Plant trials are recommended for determining suitable carbon equivalent charges for various grades of steel. F. W. BOULGER

Metal Progress

# Bulletin Board...

The Buyers Guide For Metals Engineers

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| MODEL NO. | FIRING CHAMBER (H.W.D.) | PRICE (300° to 2050°) | PRICE (400° to 2300°) |
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| P48 | 4½"x4½"x8" | $90.00 | $110.00 |
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| P414 | 14"x14"x14" | $525.00 | $603.25 |
| P124 | 12"x12"x24" | $715.00 | $822.25 |
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- Infinite zone temperature control
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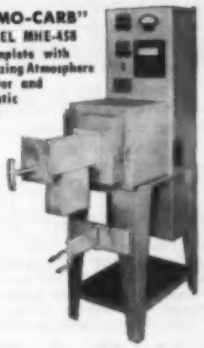
Complete with Carburizing Atmosphere Generator and Automatic Control



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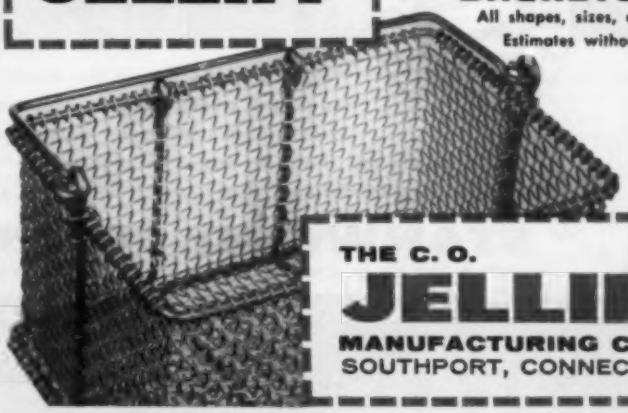

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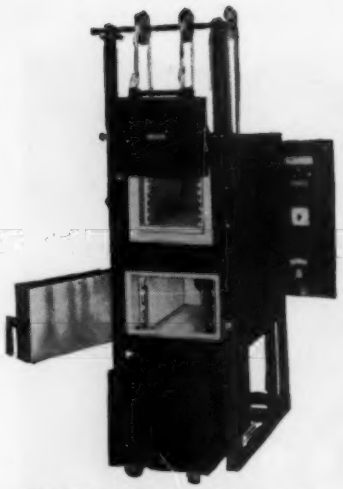

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## COMBINATION MODEL

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Drawing furnace has a maximum of 800° F.* Quench tank included with the exception of the largest standard model.

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| *Model* | *H.* | *W.* | *L.* | *2000° F.* | *2300° F.* |
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*Also available up to 1250° F.

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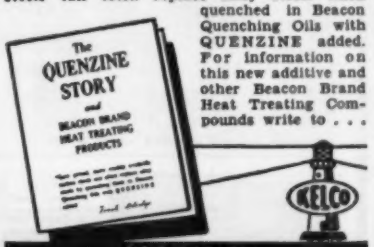


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## PLATE POTS

*Last longer.... cut operating costs*
*fast delivery..low cost*

*Before* you buy any salt pot, or if you have other heat and corrosion resistant problems —SEE WIRETEX.

**WIRETEX PLATE POTS withstand temperatures up to 2100°! Cut neutral or cyanide bath costs! Last 15 to 20% longer! Operating costs drop 25 to 35%! Down time is almost halved!**

- All metals
- I.D. dia. up to 24" and larger
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- Stress relieved
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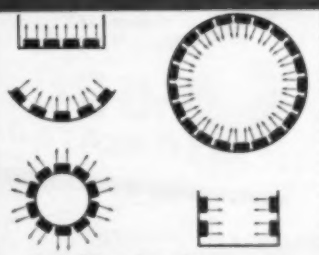
## ULTRASONIC CLEANING



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Transducer Radiating Areas of ¼ sq. ft. to 10 sq. ft. — for use in solvents and detergents.

Eliminates hand operations — Reduces rejects in plating, finishing, assembly.

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|---|---|---|---|
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| 36x72x23 | G.E. | 72KW | 2000°F |
| 48x84x24 | American | 100KW | 1850°F |
| 24x36x14 | Surface | Gas | 1850°F |
| 54x96x24 | Surface | Gas | 1850°F |

**PIT TYPE**

| | | | |
|---|---|---|---|
| 20x22 | G.E. | 48KW | 1200°F |
| 28x28 | Lindberg | 52KW | 1250°F |
| 48x72 | Lindberg | Gas | 1250°F |
| 48x96 | Surface | Gas | 1250°F |
| 48x96 | Lee Wilson | Rad. Tube | 1850°F |

**CONVEYOR TYPE RECIRCULATING**

| | | | |
|---|---|---|---|
| 72x40'x30 | Surface | RlrHrth Gas | 1250°F |
| 27x15'x12 | R&S | MshBlt Gas | 1250°F |

**BOX TYPE RECIRCULATING**

| | | | |
|---|---|---|---|
| 6'x12'x42" | Lindberg | Gas | 1250°F |
| 66"x16'x76" | Lindberg | 180KW | 1250°F |
| 60"x10'x42" | Lindberg | 180KW | 1250°F |
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**BOX & CONVEYOR OVENS**

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|---|---|---|---|
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| | | | |
|---|---|---|---|
| 18"x42"x12" | Lindberg Pshr | 60KW | 2500°F |
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# PRECIOUS METALS FOR INDUSTRIAL PLATING

**BRIGHT GOLD**

Mirror-bright finish in any thickness directly from the bath. Patented

**PUR-A-SALTS**

Restores contaminated cyanide plating baths to full, trouble-free operation. Patented

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Crystal-clear solution that produces mirror-bright deposits. Patented

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Non-dusting—safest and easiest to use.

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Brilliant, fine-grained non-tarnishing deposits.

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Only rhodium electroplating process that yields extra heavy compressively stressed deposits. Patent Pending

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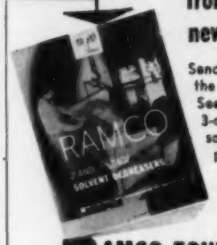


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**RAMCO EQUIPMENT CORP.**

DIV. OF RANDALL MFG. CO., INC.

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How Roll Coater

*Pre-Painted*

METAL SAVED MONEY AND IMPROVED QUALITY ON

**R-C-000 LICENSE PLATES**

**PROBLEM:**

Stello Products Company, Logansport, Indiana, manufacturer of tags, license and "booster" plates, had the problem of excessive direct labor charges. In the previous expensive method of making these items, plates had to be stamped from bare metal —and then cleaned individually—and spray painted on both sides. This method did not give the uniform quality demanded—and Stello turned to Roll Coater for a solution.

**SOLUTION:**

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**Roll Coater**

INCORPORATED

PENDLETON, INDIANA

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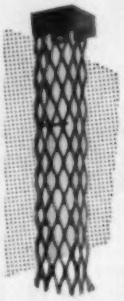

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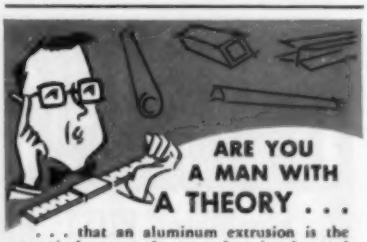

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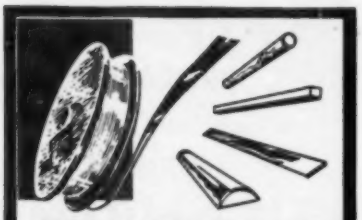

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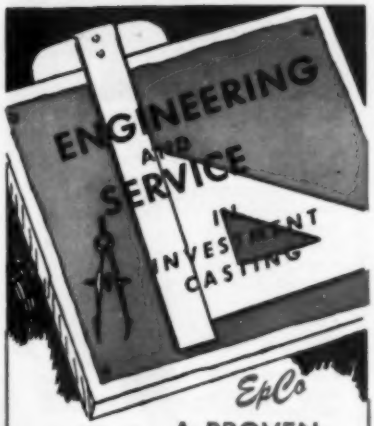


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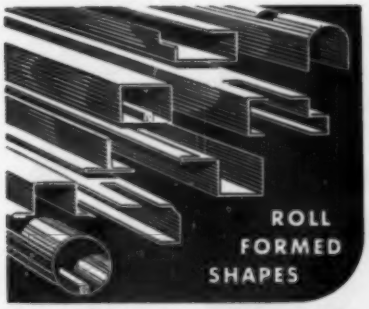


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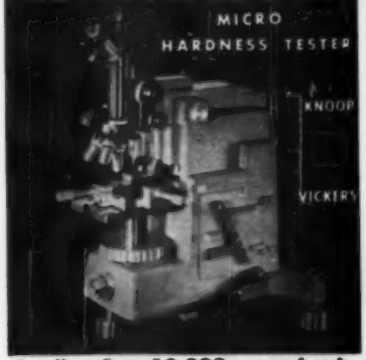


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**FAST... ACCURATE NON-DESTRUCTIVE DIRECT-READING**

- Instantly measures the thickness of metallic and non-metallic coatings and films
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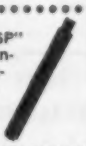

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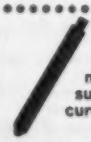

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FOR VICKERS AND KNOOP HARDNESS

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## Titanium Industry . . .

(*starts on p. 97*)

H. B. Goodwin of Battelle Memorial Institute in March 1957 reported that the Government's research effort on titanium involved 492 completed and 174 current projects, a total of 666. Expenditures for the 521 whose costs were known were about $50,000,000, almost wholly financed by Research and Development of the Dept. of National Defense. Of the total of 597 contracts for research and development, 446 had been completed and the total cost for 359 of them came to $21,816,217; 151 contracts are still current and expenditures on 111 of them totalled $21,234,618.

In the research and development category, 51% of the expenditure was for processing research, 11% for studies of properties, 14% on physical metallurgy, 22% on application and design, with 2% unclassified. Almost half the total concerned improvement of end items or components through substitution or use of titanium. Much of this expense, therefore, might be debited to other objectives than titanium research and development. An important current investigation is the "Titanium Alloy Sheet Rolling Program", which will be described in some detail in a subsequent article.

From the above, it will be seen that the accusation that the titanium program is a billion-dollar blunder is a very considerable exaggeration.* Even if many marginal items are included the sum is much less, and intangible credit items – technological benefits to the aircraft and other industries – would be hard to assess, even to a given order of magnitude. Excluding funds spent by the Bureau of Mines and a few other agencies out of their regular appropriations, the titanium expansion program has

*It may have arisen from the over-all limitation of $895,000,000 established for the total turnover or gross transactions, but this had no practical significance. Gross transactions for the certified program as revised on June 30, 1957, were $218,096,000, with probable ultimate net cost to the Government of less than half that sum, namely $107,664,000.


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## Titanium Industry . . .

been paid for almost entirely by the Department of Defense and by allotments authorized by the Defense Production Act.

Probable ultimate net cost to the Government of the titanium expansion program (principally for production facilities) will be about $110,000,000. Research activities may add another $60,000,000. An additional item should be some fraction of the accelerated tax amortization on about $160,000,000 worth of plant. All this together would came to approximately one quarter of the billion-dollar figure bandied about. That this is not money down the drain may be asserted with confidence; private industry – such realistic firms as Du Pont, Mallory-Sharon Steel, National Lead, Allegheny Ludlum Steel, Crucible Steel – have put their own money, in amounts variously estimated at $75,000,000 to $100,000,000 into the titanium expansion program. In fact, all new plant capacity planned after 1954 has depended on private capital.

### Administration

As a footnote to the above, a brief statement is warranted to summarize the administrative agencies and advisory groups which have been intimately associated with this titanium program. It will give some idea as to how the program was planned, the anticipated goals to be met, and the governmental machinery involved.

In 1953, the over-all responsibility for the titanium program was vested in the Office of Defense Mobilization (ODM) which, in turn, delegated sponge production to the General Services Administration, mill production and distribution to the Business and Defense Services Administration (Department of Commerce), and research and development as well as military requirements to the Department of Defense.

**Military requirements,** estimated by the Department of Defense, were the basis for determining production capacity. In August 1954, a Steering Group on Titanium Research and Development was set up under the Assistant Secretary of Defense for Research and Development to

X-ite

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## Titanium Industry . . .

coordinate Army, Navy, and Air Force efforts and to formulate departmental policy on titanium. The chairman is John Garrett. Later, the Defense Department's Coordinating Committee on Materials was established and the Steering Group then became in effect a subcommittee of this larger group.

**Civilian requirements** were estimated by the Business and Defense Services Administration. BDSA Order M-107, dated May 19, 1954, authorized producers of titanium mill products to release as much as 10% of their monthly output for civilian uses to expand output and development along normal lines. (Actually 98% has been used for military purposes.) On Sept. 27, 1957, BDSA raised the proportion to 25% and on Jan. 14, 1958, the order was revoked.

Prior to 1953, recommendations for facilities for sponge production were made by the General Services Administration (GSA), but ODM then delegated the responsibility for studying proposals concerning raw material supply to an assistant secretary of the Interior Department. Requests for tax amortization certificates by sponge manufacturers were reviewed by the General Services Administration. However, actual granting of the certificates remained the responsibility of the ODM. Financial aid for the exploration of domestic deposits is allocated by the Defense Minerals Exploration Administration in the Interior Department.

The Bureau of Mines, also in the Interior Department has made important contributions to the titanium industry, including economic and statistical services as well as technological research and development work done both under its regular appropriations and under grants of funds from GSA and various defense agencies.

The Government's Titanium Advisory Committee was established by ODM on Feb. 17, 1954, with Prof. Herbert H. Kellogg of Columbia University as chairman. Other members were Albert J. Phillips, vice-president of American Smelting & Refining Co., and Felix Wormser, then Assistant Secretary of Interior

# The 13th METALLOGRAPHIC EXHIBIT

## Cleveland, Ohio, October 27 to 31, 1958

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Exhibitors do not need to be members of the American Society for Metals.

Work which has appeared in previous metallographic exhibits held by the American Society for Metals is unacceptable.

Photographic prints should be mounted on stiff cardboard, extending no more than 3 in. beyond edge of print in any direction; maximum dimensions 14 by 18 in. (35 by 45 cm.). Heavy, solid frames are unacceptable.

Entries should carry a label on the *face of the mount* giving:

Classification of entry.

Material, etchant, magnification.

Any special information as desired.

The name, company affiliation and postal address of the exhibitor should be placed on the *back of the mount* together with a request for return of the exhibit if so desired.

Entrants living outside the United States should send their micros by first-class letter mail endorsed "Photo for Exhibition—May be Opened for Customs Inspection".

Exhibits must be delivered before Oct. 15, 1958, either by prepaid express, registered parcel post or first-class letter mail, addressed:

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Class 1. Cast irons and steels.

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Class 6. Uranium, plutonium, thorium, zirconium and reactor fuel and control elements.

Class 7. Metals and alloys not otherwise classified.

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Class 9. Welds and other joining methods.

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Class 11. Slags, inclusions, refractories, cermets and aggregates.

Class 12. Electron micrographs.

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### AWARDS AND OTHER INFORMATION

A committee of judges will be appointed by the Metal Congress management which will award a First Prize (a medal and blue ribbon) to the best in each classification. Honorable Mentions will also be awarded (with appropriate medals) to other photographs which in the opinion of the judges closely approach the winner in excellence. A Grand Prize, in the form of an engrossed certificate and a money award of $500 from the Adolph I. Buehler Endowment will also be awarded the exhibitor whose work is judged best in the show, and his exhibit shall become the property of the American Society for Metals for preservation and display in the Society's national headquarters in Cleveland.

All prize-winning photographs will be retained by the Society for one year and placed in a traveling exhibit to the various Chapters.

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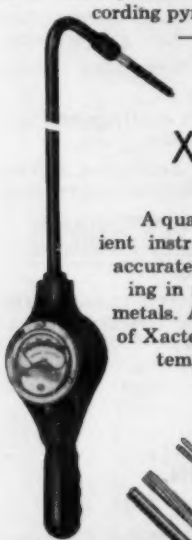

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## Titanium Industry . . .

for Mineral Resources. N. C. Fick was the executive officer. Membership was later expanded to include also the Assistant Secretary of Defense (Supply and Logistics), the Assistant Secretary of Defense (Research and Development), and the Assistant Secretary of the Air Force (Materiel). The purpose of this committee has been to coordinate Federal policies and programs for titanium and to collect and disseminate technical information. Its meetings were attended by advisors from the Interior Department, Commerce Department, ODM, GSA, Department of Defense and each of the three military arms, and the Materials Advisory Board. Minutes of these meetings (the 24th was held Aug. 8, 1957) are classified "Confidential". This committee, during its early history, restrained the enthusiasm which threatened to expand sponge metal production capacity beyond the bounds that ODM deemed advisable and reasonable.

Operating under Business and Defense Services Administration (BDSA) is the Titanium Producers and Fabricators Industry Advisory Committee composed of members from all ten companies comprising the industry. Harry B. Sharpe is the Government's presiding officer. Representatives of other agencies and the Materials Advisory Board likewise attend the meetings. Current requirements and industry problems are discussed at the meetings, which also are a forum for exchanging information.

The former Defense Minerals Production Administration negotiated early contracts for the expansion program but when ODM was organized, it became the source of authorizations, and the General Services Administration negotiated contracts for expanding facilities and for certain research and development projects. GSA also purchases sponge titanium for governmental inventory or revolving stockpile.

The Titanium Metallurgical Laboratory (TML) was established in March 1955 at Battelle Memorial Institute by the Department of Defense, under a $1,000,000 contract to cover operations for 18 to 24 months. It advises the Steering Group, gathers and disseminates information, gives technical advice to industry, and conducts short-range laboratory investigations. It has issued 80 technical reports on various aspects of titanium technology and over 100 technical memoranda.

When requested by any government agency, the Materials Advisory Board of the National Academy of Sciences has made studies and recommendations on metallurgical and production problems and reviewed research projects proposed by industry. A MAB panel monitors the Sheet Rolling Program which will be described in a subsequent installment.

## Die Steels for Pressure Die Castings

**Digest of "Steels for Pressure Die Casting Dies", by K. I. Bengtsson, *Metal Heat Treatment and Drop Forging*, Vol. 24, June 1957, p. 227-236.**

THE COST of die castings is influenced by the useful life of the dies used in producing them. For this reason, metallurgists are concerned with the metallurgical factors affecting the life of dies used for die casting. Heat checking and corrosion are the two most common conditions limiting die life.

In service, stresses are developed due to differences in temperature between the interior of the dies and the surface in contact with liquid metal. If the thermally produced stress exceeds the tensile strength, shallow cracks or heat checks form on the surface of the die. There are several expedients for minimizing heat checking. Preheating the dies to about 570° F. helps by reducing temperature gradients. Scratches and imperfections should be avoided because they act as stress-raisers. Surface hardening by nitriding or nitrogen-sulphur enrichment is sometimes advantageous. Both treatments are said to reduce sticking between the die and casting. Nitriding, however, is not recommended for dies to be used for copper-base alloys.

Grain-boundary attacks on the die surface can result from corrosion by the liquid metal. For instance, zinc in brass and other copper alloys can react with iron to form a low-melting

Repeatedly heated to 1830°F...

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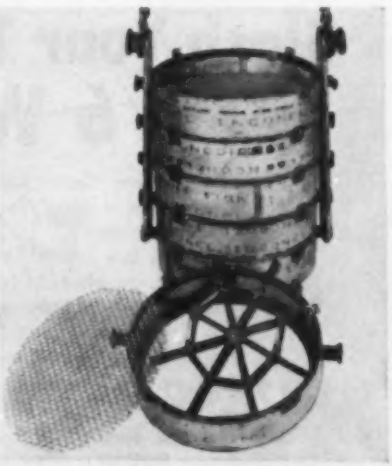

**"This shows you tray design.** Walls are solid Inconel alloy rolled and welded. Removable Inconel alloy grid and woven screen rest on shoulder."

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## Die Steels . . .

phase. Although lead does not alloy with iron, lead oxide formed on leaded copper alloys will corrode steel at elevated temperatures. Chemical attack of either type will result in stress concentrations along grain boundaries at the die surface.

Diecasting dies should have suitably high tensile strengths and be resistant to softening at operating temperatures. For aluminum or magnesium alloys, the 0.2% proof stress should exceed 17,000 psi. at 1300° F. For copper alloys, the proof stress should be not less than 8500 psi. at 1475° F. To avoid early heat checking, the steels should retain their tensile strength for a long time at elevated temperatures. The hardness of some of the common Swedish die steels mentioned only drops from about Rockwell C-46 to 28 during tempering for 260 hr. at 1115° F. The hot hardness of the die steels range from Vickers 175 to 350 at 1115° F.

These properties are obtained by using balanced amounts of alloying elements. Carbon contents are limited 0.40% to minimize brittleness. Chromium, in amounts up to 12%, is added to confer hardenability and resistance to tempering. Molybdenum (to 2%) and tungsten (to 12%) confer high-temperature strength. Vanadium is used to inhibit grain coarsening during heat treatment. Cobalt is sometimes employed because it gives better resistance to tempering.

Variations in thermal conductivity among hot working die steels influence the thermal stresses near the surface caused by contact with molten metal. High thermal conductivity, over 0.070 cal. per °C. per sq.cm. per cm. per sec., around room temperature is desirable. All alloying elements except cobalt decrease conductivity. On a weight basis, they rate in the following (decreasing) order of potency; silicon, nickel, vanadium, molybdenum, chromium and tungsten.

Care must be taken to avoid decarburization during heat treatment. At least two tempering treatments are essential. It is desirable to stress-relieve the dies occasionally in order to prolong their life.

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## Disposal Plant for New Plating Facility

Digest of "Planning and Operating an Industrial Waste Disposal Plant for a New Plating Facility", by G. J. O'Kane, *General Motors Engineering Journal*, January - February-March 1958, p. 8-11.

THE OPPORTUNITY to install a preventive waste treating system was presented when the Columbus, Ohio, plant of Ternstedt Div., General Motors Corp., expanded its manufacturing operations. In the new plant, metal plating operations which produce cyanide wastes were to be installed. This required a waste disposal system and it could be designed concurrently with the planning of the manufacturing process. The result was the design shown on p. 180 which produces an almost colorless, clear effluent, completely absent of any detectable cyanides, cyanates, chromic acid or copper.

The cyanide waste is piped to one of three 25,000-gal. concrete tanks where it is chlorinated with automatically controlled pH. An oxidation reduction potential meter indicates the changes taking place. Both cyanides and cyanates are destroyed before the treated water enters the general waste treatment flow for clarification.

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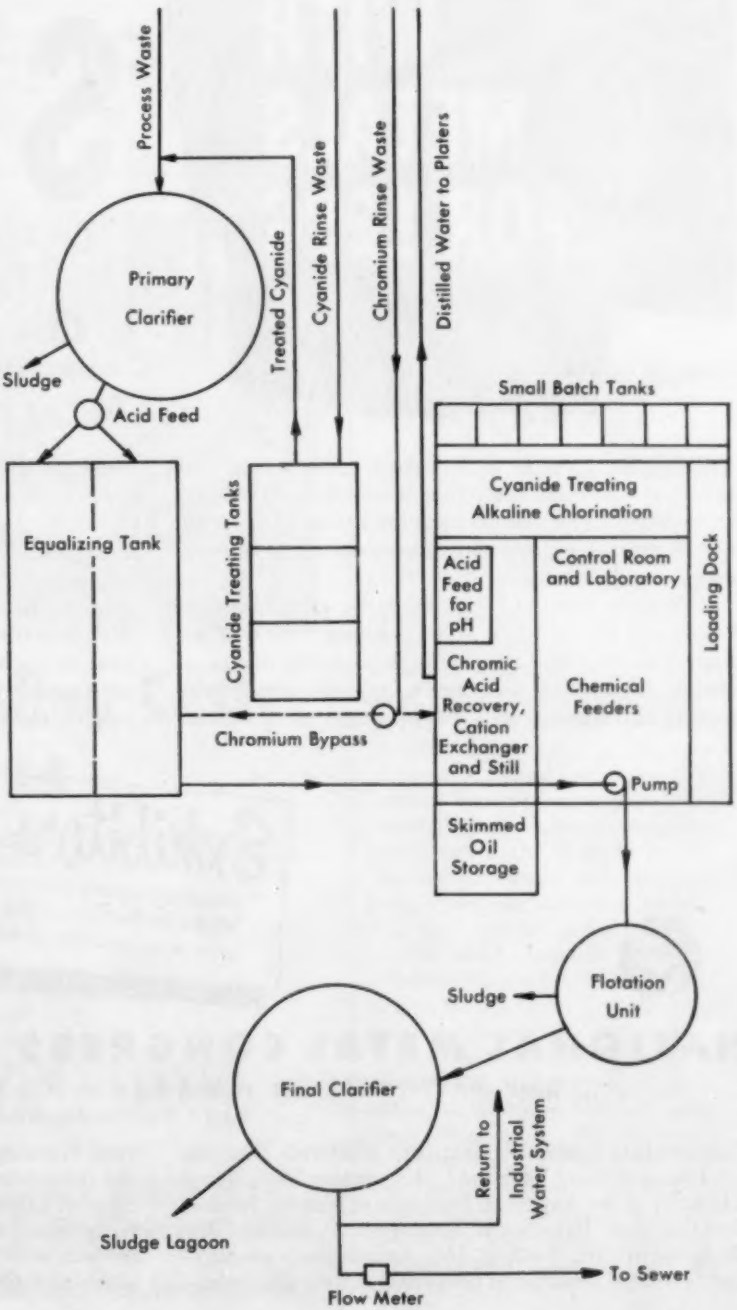

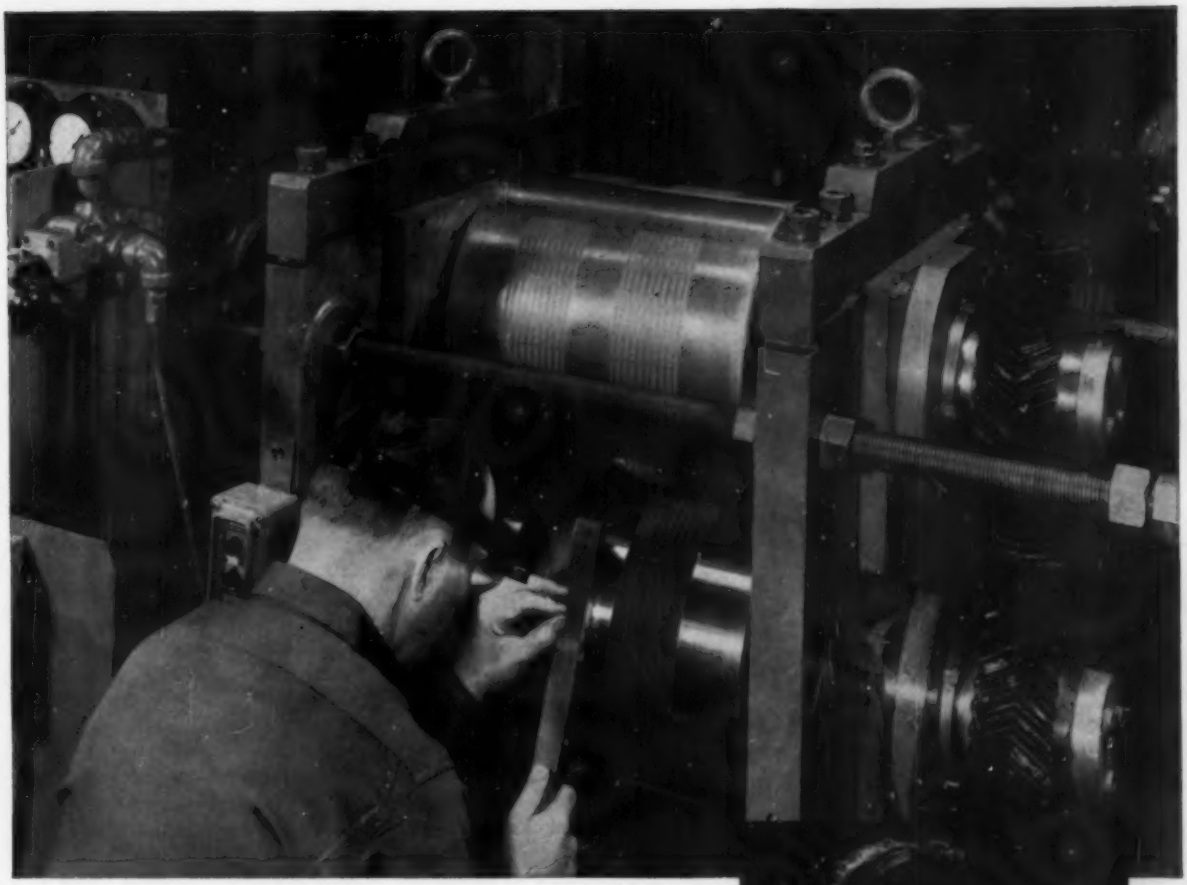

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Next, it is pumped into an air flotation unit at a pH of 4 or 5, depending on whether chromium is present. Ferrous sulphate is added at a predetermined rate. The suspended oil is floated off and lagooned with the sludges.

The effluent goes to a recirculated sludge clarifier (40 ft. in diameter) which has a chemical mixing well where lime is added to bring the pH to 9 or 9.5. This is maintained by an automatic pH control on the lime feeder. The sludge is blown off by gravity at timed intervals into a 20,000-gal. sludge storage tank from which it is pumped to the sludge lagoon.

The effluent then flows into a sewer where it joins the sanitary wastes and then into the Columbus sewer system. Part of the effluent is returned to an industrial water system in the waste plant to be used for chemical mixing, and other necessary purposes.

The disposal plant is designed to require the minimum of personnel and afford a maximum of flexibility. All major valves are remote air operated and may be controlled from a central control room which also contains all the recording controlling pH meters, flow gages and tank depth gages. All pH cells are in this room and samples are pumped to them as well as to a sink where samples from practically any process can be obtained A. G. G.

## Overheating Effects in Aluminum Alloys

Digest of "Overheating Effects in High Strength Aluminum Alloys", by T. R. G. Williams, *Metallurgia*, Vol. 56, July 1957, p. 33-37.

THE OVERHEATING of duralumin during heat treatment leads to objectionable microstructures that can cause blistering of the surface or cracks during rolling. Overheating can occur either when ingots are homogenized, or when the solution heat treatment is applied to the rolled alloy, since both of these treatments are most effective at a temperature only a few degrees below that producing the overheated structure.

The overheated structure produced during the solution heat treatment has been previously described. It is typified by rosettes and intergranular films of liquated intermetallic constituents, the alloy adjacent to the rosettes or films being generally denuded of the fine dispersion present elsewhere. In severe overheating during the solution heat treatment of the rolled alloy, continuous grain-boundary films may be formed that are similar to the network normally occurring in castings.

Overheating in the preheat homogenization treatment occurs either because the temperature rose higher than specified, or because of excessive coring in the ingot structure, giving locally an abnormally low solidus temperature. Rosettes of liquated intermetallic constituents are formed on overheating during homogenization as well as when the overheating occurs during the solution heat treatment, and it has been difficult to determine just which treatment was responsible when overheating was detected in the finished product.

To determine whether overheating during homogenization could be distinguished metallographically from overheating during solution heat treatment, the microstructure of some duralumin, overheated only during homogenization, was compared with the previously known microstructure of this alloy overheated in the solution treatment. For this purpose, a sample of an ingot of duralumin that showed a critical point at 950° F. on heating was homogenized 12 hr. at 970° F., rolled and annealed at 860° F., and solution heat treated for 1 hr. at 930° F. Liquation was clearly detected, as expected, after the preheat homogenization, and irregular films between groups of intermetallic constituents were found in the final structure. The rosettes formed during liquation were not broken up or otherwise altered in rolling. The final etched microstructure showed brighter areas where the overheating was more severe and the intermetallic constituents were more segregated in streaks than in the darker etching areas. These streaks repre-

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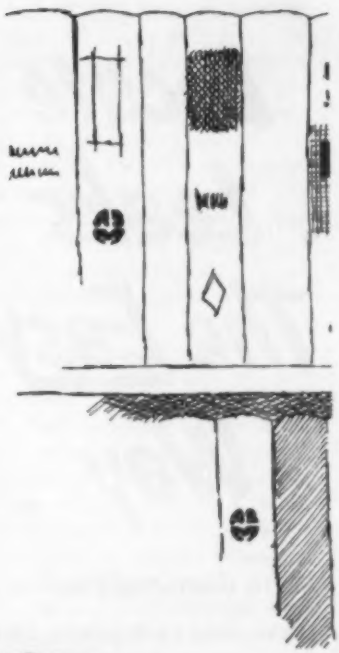

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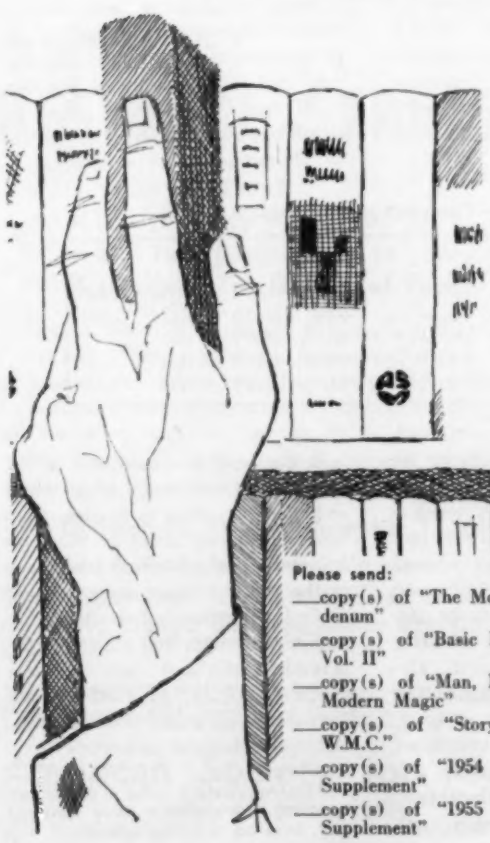

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## Overheating . . .

sented liquation films, and they occurred between grains of the original cast structure, forming a coarse cellular pattern. The recrystallized grain boundaries within those cells were free from liquation films.

This forms the basis for a metallographic distinction between duralumin overheated in the two different steps of the processing. If the liquation films follow the recrystallized grain boundaries, overheating occurred in solution heat treatment, and if they are found only between the cells of the cast structure, overheating occurred in homogenization.

GEORGE F. COMSTOCK

## Welding Titanium

Digest of "A Contribution to the Problem of Welding Titanium Alloys", by Karl Bungardt and Klaus Rüdinger, *Zeitschrift für Metallkunde*, Vol. 47, August 1956, p. 585-593.

FAVORABLE STRENGTH to weight ratios are now figuring in many decisions to use the titanium and titanium alloys, shown in Table I, as structural materials in corrosive applications. In many instances, especially in the chemical industry, the durability and strength of the weldment is important.

Because of titanium's affinity for the embrittling elements oxygen, nitrogen and hydrogen, a welding process must be selected which provides adequate safeguards against gas absorption. The welding and heat affected zones must be descaled effectively, and a shielding atmosphere must be provided. Descaling can be either mechanical by grinding or chemical by pickling. The latter process is preferred; however, it is important to avoid any embrittling by hydrogen absorption. An additional danger exists with exceptionally thin-walled pieces, where, because of the high hardness of the scale combined with the severe application of the grinding wheel, local overheating may take place. This may lead to embrittlement and renewed scaling.

An argon or helium protective atmosphere, or mixtures of the two, using direct current to supply the arc, is recommended. The protective gas, shielding the arc from the outside atmosphere, should be of the highest purity commercially obtainable. Some investigators have used specially constructed "protective chambers" which are filled with an inert gas but this method has obvious economic drawbacks.

The welding current amperage presents a unique problem since it must be carefully balanced so that on the one hand the welding velocity is fairly rapid and, on the other hand, the heat absorption of the material is kept at a minimum.*

The flow of protective argon must be sufficiently rapid to prevent excessive vaporization of the tungsten welding electrode. If, however, the amount of argon is excessive, blisters show up in the welding beads.

Better mechanical properties of welded joints were obtained in experiments where a titanium filler rod was used. The quality of the filler is, of course, influential. Only insignificant differences in the parent metal hardnesses were observed.

**Table I — Composition of Titanium Alloys**

| ALLOY | FE | CR | AL | SN | C | N | H | O |
|---|---|---|---|---|---|---|---|---|
| 1 | 0.12 | — | 0.11 | — | 0.045 | 0.013 | 0.0056 | 0.094 |
| 2 | 0.27 | — | trace | — | 0.02 | 0.019 | 0.0125 | 0.304 |
| 3 | 0.26 | — | 0.08 | — | 0.015 | 0.027 | 0.007 | — |
| 4 | 0.23 | — | 4.3 | 2.4 | 0.035 | 0.010 | 0.006 | *(a)* |
| 5 | 1.68 | 2.98 | 0.06 | — | 0.015 | 0.015 | 0.003 | *(a)* |

*(a)* Not determined.

If the bead is sound and a test specimen containing a titanium weldment is pulled in tension, fracture will always occur in the base material. Should failure take place in the welded zone, embrittlement or faulty practice is indicated. Titanium-chromium-iron alloys are inherently brittle, and a postweld heat treatment (4 hr. at 1200° F. for instance) is necessary to obtain satisfactory mechanical properties.

*Unfortunately for American readers, the authors have omitted any data on welding speeds.

Generally speaking, a postweld anneal is recommended for all alloys (1 hr. at 1290° F.) to reduce residual stresses and improve notch toughness. Section thickness of the weldment affects the length of time required at temperature.

Weldments made up of both $\alpha$ and $\alpha + \beta$ titanium alloys exhibit superior properties. However, even in the case of sound welds, fractures occur in or near the welded joint when specimens are tested in tension.

HANS HEINE

## The Titanium Situation

Digest of "Present Status and Future of the Titanium Industry in the U.S.", by Herbert H. Kellogg. Paper read Aug. 30, 1957, before the Swiss Assoc. for Testing Materials and printed in *Schweizer Archiv für Angewandte Wissenschaft und Technik* (Swiss Journal of Applied Science and Technology), January 1958.

THE SUDDEN CONTRACTION in demand and production of titanium at the middle of 1957 warrants a re-examination of the published estimates of future expansion of this industry. Sponge production, about 2500 tons in 1953 at $5 per lb., jumped up as governmentally financed plants came into operation, to 5000 tons in 1954, 8000 tons in 1955 and 12,000 tons in 1956 (by which time the price of sponge had been reduced to about $3). Production for 1957, as estimated earlier, was to be about 18,000 tons.

Consumption of mill products lagged far behind, reaching 2000 tons in 1955. By that time the hydrogen-embrittlement problem was solved, and 5100 tons were used in 1956. The consumption estimated at the beginning of 1957 (10,000 tons) did not materialize; probably no more than 6500 tons actually were used.

Aside from the hydrogen problem, the cause of the first slump in 1954 and 1955 was due to the lack of confidence. Aircraft and aircraft engine designers were not convinced that the new material would be all that was claimed for it nor that it would be available in proper quality and quantity. Consequently they continued to design in steel or aluminum, and what titanium actually was used was merely as a substitute and hence the maximum savings in poundage were not achieved. The present slump results from the curtailment of the military aircraft program, rather than from inherent shortcomings of titanium. The long "lead time" for the development of new uses of titanium indicates that as much as three years will be required to recover from the present slump.

However, there is every reason to believe that this will occur, and this belief has a sound basis:

There is abundant titanium in the earth's crust. A pound of titanium in illmenite concentrate costs 4¢. Compare this to 1¢ for iron in hematite or aluminum in bauxite, or $1.00 for metal in concentrates of columbium or molybdenum.

Its chemical properties are such that it is almost completely resistant to dilute chlorides (sea water) and ambient atmosphere. It also has unequaled resistance to solutions containing chlorides if a small amount of oxidizing agent is present, hot 60% nitric acid, hot sulphuric


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## Titanium . . .

acid in the presence of oxygen under pressure, hypochlorite solutions and synthetic urea.

Its combination of high creep strength when alloyed and low specific gravity, even when working temperatures reach 1000° F., is the basis of its present use in aircraft engines and will warrant many future applications in all transportation and in portable machinery.

Most of the obvious uses of such a versatile material depend on economics. The uses will expand as the price is reduced.

The author is not inclined to revise very much his appraisals made in 1955 of future prices [which by the way are in the same range as six other analyses published by others]. Estimates for future costs of sponge and average mill products are compared at the top of the page.

"It is now time to re-examine the market possibilities of titanium, in the light of the estimated prices, to see if a market of 100,000 tons or more per year in the U.S. is possible.

**Titanium Cost and Production Estimates**

| Time | Sponge | Mill Products |
|---|---|---|
| Estimated cost for 1957 | $2.25 per lb. | $11.50 per lb. |
| Annual production | 15,000 tons | 6500 tons |
| Estimated cost for 1961-1965 | $1.50 to 1.75 | $7.50 to 6.50 |
| Necessary production | | 20,000 tons |
| "Mature future" | $1.00 to 1.30 | $2.10 to 3.50 |
| Total market | | 100,000 tons |

When titanium sells for $1.15 per lb. as sponge and $2.50 per lb. for mill products, it will still not be considered a cheap metal. It obviously will not be competitive with structural steel which sells for 5¢ per lb. as mill products. Large-scale use of titanium for building construction and bridges is most unlikely, even should the cost drop to a much lower figure.

"Titanium, even at estimated maturity prices, will still be three to five times as expensive per pound as aluminum, stainless steel or copper alloys. It is not likely, therefore, to replace these metals for those applications where the cheaper metals can do the job just as well.

However, there are many places where it can outperform other metals in applications requiring high strength-to-weight ratio up to 1000° F. or requiring titanium's special corrosion resistant properties. There will certainly be numerous applications where improved performance will more than repay the extra.

"It is worth pointing out that the nickel industry is now close to 200,000 tons per year in size, and that the current price of nickel cathodes – $0.74 to $1.05 per lb. – is not greatly different from the eventual price of $1.15 for titanium sponge. I think it most likely that the titanium industry will achieve a size and prices comparable with those of the nickel industry."

E. E. T.


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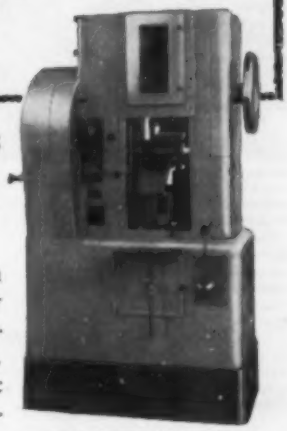
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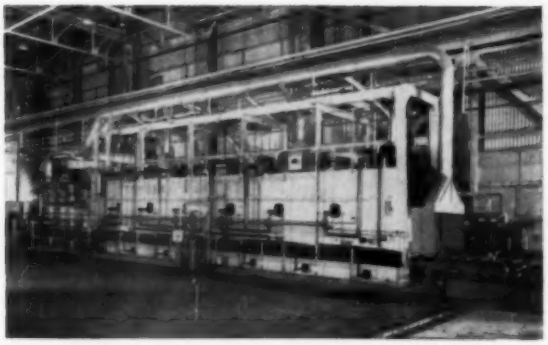

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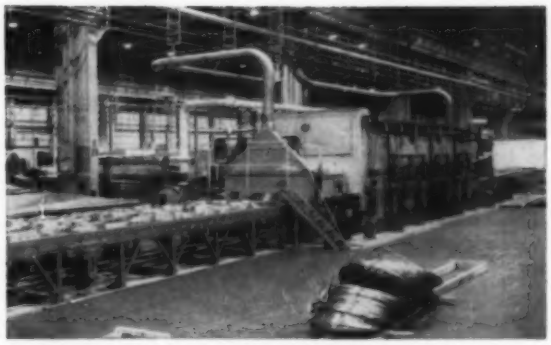

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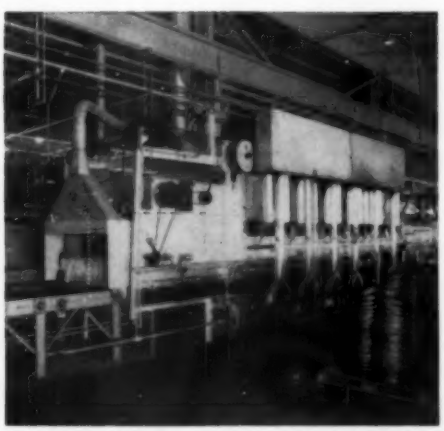

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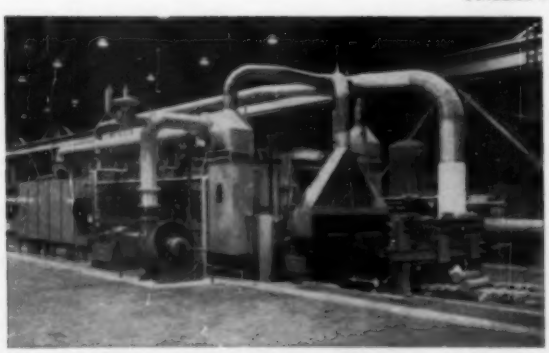

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